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ABSTRACT

This report describes the Generalized Maintenance Trainer-Simulator (GMTS), an instructional system designed to give electronics students intensive troubleshooting practice in a simulated hands-on training environment, and reports on a field evaluation of the GMTS applied to systems level troubleshooting in radio communications. The GMTS can be used for any device in which signal paths and their relationships to controls, indicators, and test points can be defined. It generates interaction with the student by referring to his last inputs and to its stored history of interactions with him up to that point. To the extent that these individual student histories constitute models of individual students, GMTS constructs a model of each student to interact with that student. The computer program that implements the instructional system is indifferent to the specific equipment being taught, since specific equipment for simulation is determined by loading two bases for that equipment describing its essential features. Results of field evaluation of twenty students who practiced solving 35 troubleshooting problems were: (1) more uniform fluency at troubleshooting; (2) decrease in mean times to solve a problem; and (3) a more favorable attitude toward the trainer. (Author/CWM)

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DEPARTMENT OF PSYCHOLOGY

UNIVERSITY OF SOUTHERN CALIFORNIA

BEHAVIORAL TECHNOLOGY LABORATORIES

Technical Report No. 89

FIELD EVALUATION OF THE GENERALIZED MAINTENANCE TRAINER-SIMULATOR: I. FLEET COMMUNICATIONS SYSTEM

October 1978

J. W. Rigney, D. M. Towne, C. A. King,
and P. J. Moran

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to that point. To the extent that these individual student histories constitute models of individual students, GMTS constructs a model of each student to interact with that student. In addition to these features, GMTS is uniquely suitable for use in Class C school training. The computer program that implements the instructional system is indifferent to the specific equipment being taught. What specific equipment that is simulated by the GMTS is determined by loading two data bases for that equipment: one describing essential internal features of the equipment and the other describing the external features.

This is a report of a field evaluation of the GMTS applied to systems level troubleshooting in the UHF communications side of the Fleet Communications System. Twenty Class A school students waiting to enter C schools practiced solving thirty-five troubleshooting problems. Results were generally positive. The students became uniformly more fluent at troubleshooting; mean times to solve a problem were decreased by a factor of two, and standard deviations of these times were decreased by a factor of five. Also, students' attitudes toward the trainer were generally favorable. An additional field trial is underway, using the AN/SPA-66 radar repeater as the subject matter.

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SUMMARY

The Generalized Maintenance Trainer-Simulator (GMTS) is a concept for giving students in Class C schools intensive practice in troubleshooting equipment and systems taught in those schools. It can be used for any device in which signal paths and their relationships to controls, indicators, and test points can be defined. The GMTS uses generative CAI. That is, it generates the interaction with the student by referring to his last inputs and to its stored history of interactions with him up to that point. To the extent that these individual student histories constitute models of individual students, GMTS constructs a model of each student to interact with that student. In addition to these features, GMTS is uniquely suitable for use in Class C school training. The computer program that implements the instructional system is indifferent to the specific equipment being taught. What specific equipment that is simulated by the GMTS is determined by loading two data bases for that equipment: one describing essential internal features of the equipment and the other describing the external features.

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TABLE OF CONTENTS

Section		Page
I.	INTRODUCTION	1
II.	OPERATING FEATURES OF THE GMTS	6
	GMTS Configuration New Settings GMTS Data Base	
III.	THE FIELD EVALUATION SITE AND SUBJECTS	20
	Results	
IV.	CONCLUSIONS	25
	REFERENCES	26
	APPENDIX A. UHF VOICE COMMUNICATIONS SYSTEM TECHNICAL MANUAL	27
	APPENDIX B. UHF VOICE COMMUNICATIONS SYSTEM TROUBLESHOOTING TREE	78

LIST OF FIGURES

Figure		Page
1.	GMTS Configuration	7
2.	Electronic Pen	9
3.	Command Strip	9
4.	Hierarchical Structure of a System	11
5.	UHF Communications System Top Level Diagram	15
6.	Average Solution Times Per Problem Within Blocks	22
7.	Average Extra Units Replaced per Problem Within Blocks	23

LIST OF TABLES

Table		Page
1.	Summary of Responses to Thirteen Attitude Questionnaire Items	24
2.	Means of Responses to the Following Question	24

SECTION I. INTRODUCTION

The Generalized Maintenance Trainer-Simulator (GMTS) is an instructional system designed to give students in Class C electronics schools in the Navy intensive practice in troubleshooting in a simulated hands-on training environment. The system is intended to reduce the requirements for using operational equipment in the laboratory phases of this training, and to amplify the effectiveness of students' sometimes-limited opportunities to work on real equipment by familiarizing them with its functional and structural architecture beforehand. Although real equipment undeniably is its own best simulator, provided it is functioning properly, there are many disadvantages to using operational equipment in training environments. It can be very expensive, for very large and/or complex systems. Training places unusual stresses on equipment, reducing its availability for training and increasing the cost of maintaining it, and the logistics of maintenance are burdensome on schools. It cannot be quickly reconfigured in different states. It does not incorporate an instructional system of any sort, certainly not one that includes models of functional architecture and maintenance tasks of sufficient power to allow "tracking" each individual student's progress through a troubleshooting problem. It does not incorporate other features of instructional systems, such as adaptive controllers, schedulers, or automatic data capture and analysis. It usually embodies electrical hazards, such as voltages or high frequencies. All these problems with using operational equipment for maintenance training have been listed many times before.

The GMTS is designed to avoid many of these disadvantages by a combination of low-cost simulation techniques and an automatic instructional system, but it is not intended to replace all use of real equipment in training. Its simulational bandwidth is confined to conditions and operations necessary for practicing fault localization, either from front panel information, or from information obtained from test points behind the front panel. The GMTS also is designed to be readily adapted to simulate different kinds of equipment, by changing data bases that describe functional and structural architecture (1) to the computer program that controls the simulation and interacts with the student, and (2) to the student who is interacting with the computer program. The second data base includes color and black and white microfiche images that are accessed under program control. Since cost was a major consideration in the development of the GMTS, it is based on minicomputers or microcomputers using floppy disks for extended, and open-ended memory. The rapid developments in LSI electronics undoubtedly will bring the cost of various forms of LSI memory down to the point at which floppy disks need not be used for extending storage capacity, although they might still be used for the advantages of open-ended memory. Because of the low cost objective for the development of the GMTS, certain features, such as natural language interfaces or CAD (Computer-Aided-Design) programs for computing changes in functional states, were not considered. Although these might be nice to have, the memory and processing requirements of these features so far translate into very high hardware and processing costs per student contact hour.

Thw GMTS functions completely automatically. Once a student signs on, the system proceeds to give him instruction, to track his

progress, and to record and analyze a detailed history of that progress. We do feel it is worthwhile to point out some features of the human information processing system that are worthy of consideration in relation to simulation. We believe that, as we learn more about this system, eventually it will be possible to develop a theoretical rationale for making decisions about man-machine variables in simulation.

Jerison (1973) has analyzed available data concerning the evolution of the human nervous system. Although many of his conclusions are necessarily extrapolations from limited evidence, his work is an impressive reminder of what we already know, that the human information processing system evolved as a tool for surviving in a hostile environment. It must continually try to answer the following questions about the representations of the world constructed by its perceptual systems:

1. What is it?
2. What should be done about it?
3. How is it done?
4. Is it possible to do it?
5. Am I doing it correctly?
6. Am I through?

These questions must be answered anew for each change in the perception of the internal and external worlds. In most cases, they can be answered quickly, most changes being specific examples of already familiar general cases. But, unfamiliar changes require that the system extemporize answers and try out solutions: i.e., thatit learn how to answer these questions in the new situations.

The evolution of the immense capacity of Long Term Memory allows storage of learned answers to these primitive questions. The evolution

of language, combined with long term memory capacity, allows thinking to occur in the past and the future, as well as in the present, allowing these quetions to be answered in the past and future as well as in the present tense. Education and training have become elaborate social institutions, in which students may spend months or years learning how to answer these primitive questions, in many different forms and under many different circumstances. Education attempts to provide knowledge bases that can serve to answer these questions over a broad range of circumstances. Training is concerned with teaching knowledge bases for a narrower range of circumstances.

The recent and continuing development of schema theory, as a way of modeling the contents of Long Term Memory provides a way of interrelating representational and procedural knowledge, and the different levels of abstraction, generic and specific, of perceptions, concepts and procedures. The message of schema theory is that perceptions, concepts, and procedures are represented in Long Term Memory in semantic networks that allow variations of external world objects and events without loss of meaning. A chair is recognized as a chair from many different perspectives. The same essential meaning can be conveyed by many different wordings of sentences. There are many different ways to turn a knob.

Our approach to the design of a trainer-simulator was to develop valid representations of equipment structural and functional architecture that could be used by the instructional system for teaching the student how to answer the six primitive questions in the context of fault localization, without incurring excessive costs for complete, high fidelity

simulation of all man-machine interactions, all structural and functional architecture, or all modes, or all procedures. The objective was to drive the student's information processing system to develop appropriate schematic structures in Long Term Memory. These generic schemata then should enable the student to quickly add finer-grained schemata when he begins to interact with the real equipment.

SECTION II. OPERATING FEATURES OF THE GMTS

This section contains a description of the operating features of the GMTS available to the student. Since many of the students used in the field evaluation had no prior training or experience with the UHF voice Communications System, an introductory manual, including a systems-level fault tree, was written for them to use. This technical manual was put on microfiche, so that the student could access it at any time he wished. This technical manual is reproduced in Appendix A of this report.

It must be emphasized that this application of the GMTS was aimed at Class A school students who were to be given an introduction to the Fleet Communications System on their way through Class A school, and therefore the instructional material was couched at a more introductory level than would be the case for a C school application, such as for teaching the AN/SPA-66 radar repeater. This does illustrate some of the "vertical generalizability" of the GMTS concept.

The level of detail to be simulated is flexible, and can be decided by the training staff. In this instance, the systems level was chosen to give Class A school students practice in systems level troubleshooting, without getting into troubleshooting individual equipment in the system, which would have implicated Class C school training. It would have been possible, given the requirement, to construct data bases for this equipment, as well. How far down in the equipment to go would be determined by the objectives of the training and by the scope of the circuit integration by MSI or LSI techniques.

GMTS Configuration

The hardware presented to the GMTS user is shown in Figure 1.

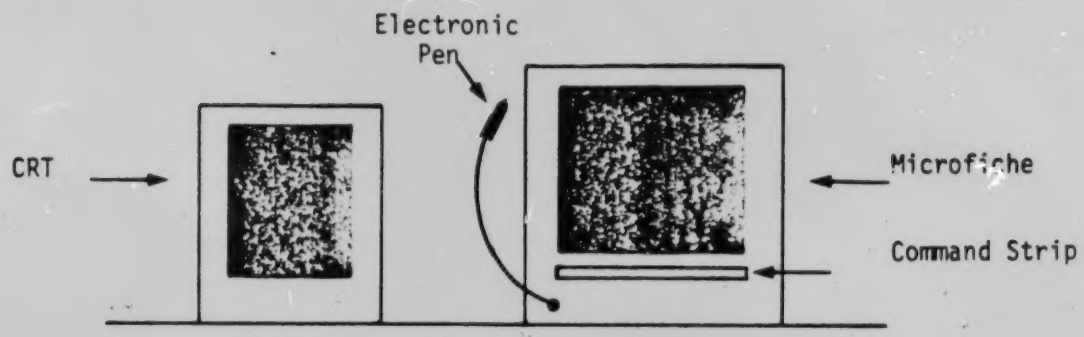


Figure 1: GMTS Configuration

The interactions between student and trainer/simulator are accomplished via these four hardware elements as follows:

1. Micrographics Screen

   Here are projected black-and-white and/or color images of text, equipment front panels, test equipment indicators, schematic diagrams, and other graphical representations of the real equipment.

2. Cathode Ray Tube

Text displayed on the CRT is dialogue between the GMTS monitor program and the student. It is here that GMTS provides direction and poses questions about the student's objectives, decisions, and perceptions as a troubleshooting problem progresses. The specific interactions provided on the CRT include:

- The student's name to verify correct log-in
- Presentation of initial operation "complaint" for the current simulated malfunction
- Directions to proceed, point to reference dot, and other directions for interacting with GMTS
- Listing of the control settings made on current image of front panel
- Questions about normality of indicators
- Status of current problem (solved or not solved).

Thus the CRT acts as a "tutor" in providing dynamic information related to particular consequences of actions by the user.

3. Touch Pen

This is an electronic stylus which is touched to the micrographics screen, and command strip described below. When the pen makes contact with these, GMTS immediately receives the X,Y coordinates of that "strike," and thereby knows where, on a photograph, diagram, or menu of commands, the student has indicated a response.

Strikes on the micrographic screen are used to request close-up views of the selected unit and to actuate switches. Strikes on the command strip indicate desired actions by the GMTS user.

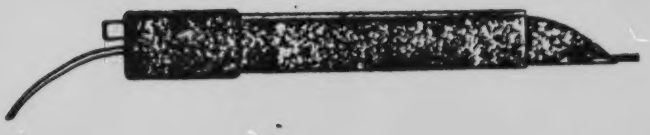


Figure 2: Electronic Pen

4. Command Strip

The command strip is shown below (approximately half-size).

Figure 3: Command Strip

The commands function as follows:

0, 1,....9, used for entering numeric data, such as student I.D. number, problem number, etc.

ENTER terminates numerical entries

REVIEW

GMTS consists of two major portions:

A. Introduction Program (Review)

B. Troubleshooting Practice Program

The introduction consists of a series of slides which are projected in response to the user touching [REVIEW]. The image initially projected is the beginning of a troubleshooting procedure called a "tree" as shown in Appendix B. The user may step through this tree to compare his trouble-shooting strategy with this one reasonable approach. Additionally, the

GMTS technical manual is part of the introductory material shown in Appendix C, and follows the troubleshooting tree. The user may return to this material during troubleshooting practice by touching [REVIEW]. In the test mode this command is inoperative.

→ and ← Indicate that the user wishes to view the next image in a sequence (→) or the prior image(s). Multiple inputs of this command quickly move the student through the sequence.

RENEW IMAGE - Occasionally the micrographics system fails to project an image. Touching [RENEW IMAGE] commands it to repeat the fiche image selection process.

PROCEED - Indicates that the student has completed reading or studying a message or graphics image and wishes to continue to the next phase or step of a sequence.

ERASE - Wipes out inputs just made on command strip.

Reference Dot

On each pictorial image, usually in the lower right-hand corner, is a reference dot (little bull's-eye). The user must point to this dot each time a new image is projected, so that the system knows exactly where the image appears on the screen. The improved repeatibility of micrographics projection equipment now available would obviate the need for this in the future.

New Settings

An equipment or system is represented as a hierarchy of images, each level of images being more detailed, close-up views of the element above. In this way systems of any size or complexity are easily photographed and projected. An example of such a structure is shown in Figure 4.

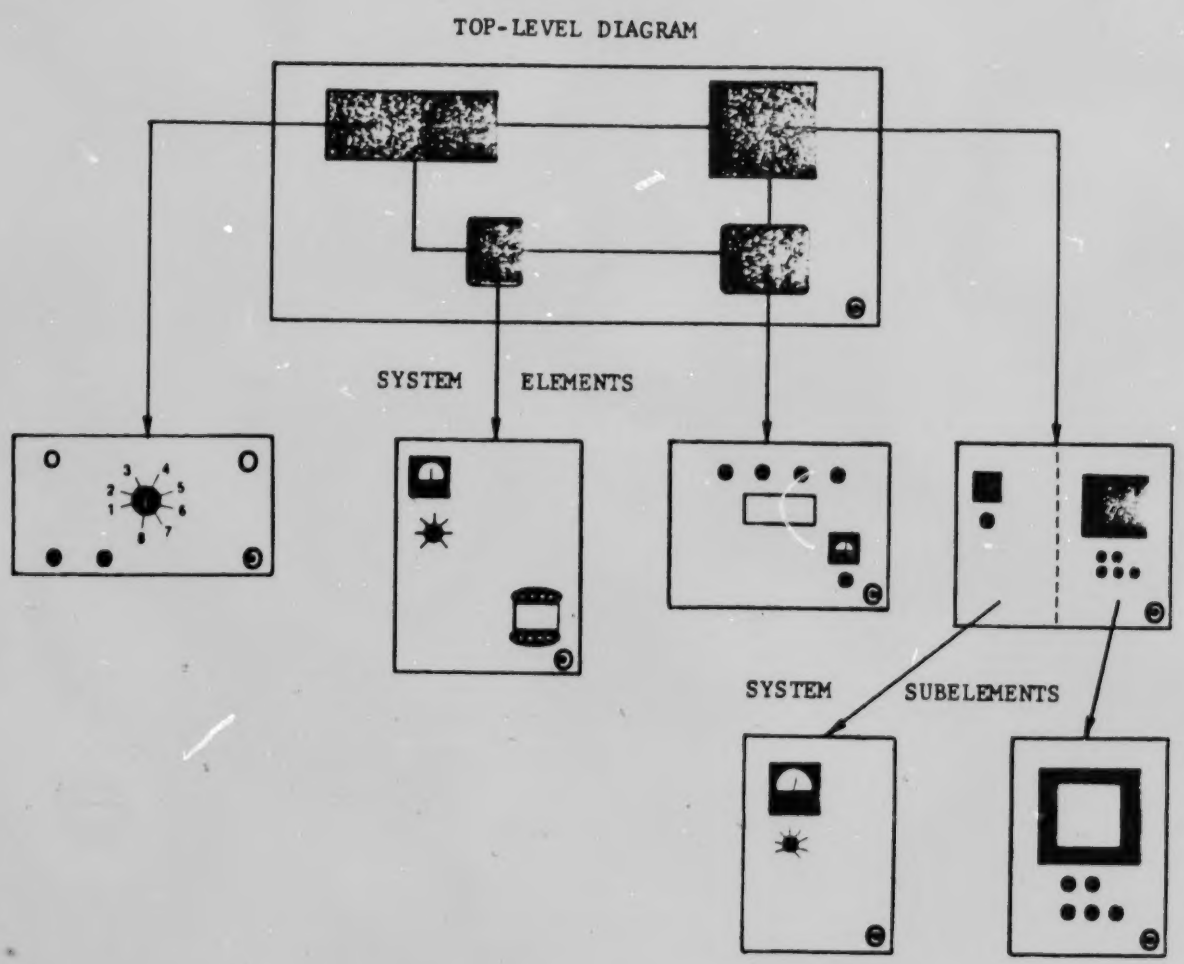
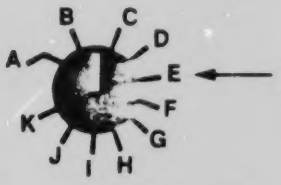


Figure 4: Hierarchical Structure of a System

The student works "down" the hierarchy by simply touching the pen to the equipment or unit he wishes to see or operate. Following each such strike a more detailed view of the selected unit is projected. Just three or four strikes typically take the student from a top-level diagram of a multi-equipment system to a small section of one sub-unit. At this point, the user may observe the indicators and current switch settings, and he may change settings by simply pointing to the settings

desired, on the panel image. This action is virtually identical to reaching out and operating the actual switch.



The user points here to set switch to Position E

As each selected switch change is sensed by GMTS, it is listed on the CRT. If a mistake is made the desired setting is simply re-selected. After all desired settings for the current panel have been made, the user points to [NEW SETTINGS]. GMTS then projects a new image with all selected settings shown. Any effects on lights, meters, etc., are also reflected at this time. Likewise any effects on other units can be determined by viewing those units.

OLD SETTINGS - To eliminate changes to switch settings listed on the CRT, the user touches [OLD SETTINGS]. This clears the CRT listing and leaves the panel in its present configuration.

UP - Pointing to [UP] returns to the previous, "higher" level image. Each successive UP command takes the user to a less detailed image, reaching the "top" level picture as a limit.

HELP - During a troubleshooting problem, a student may request help from GMTS by pointing to [HELP] on the command strip. Upon doing so, he observes a listing of system elements on the CRT. He then enters the numbers of all units which he currently suspects as possibly causing the initial complaint and the subsequent symptoms which he observed. The trainer will then place * marks next to each element which he should correctly suspect, based upon the symptoms which he received. In test modes this support features is inhibited.

REPLACE - System elements are replaced or repaired by touching [REPLACE], and then touching the number of the system element which is suspected of causing the abnormal symptoms. The student then may resume checking the equipment knowing that the replaced unit is now working correctly. If the abnormal symptoms persist, he will have to locate and [REPLACE] another element. GMTS will accummulate and record the number of times replacements are made for each problem.

DONE - Indicates that the student feels he has completed (or given up) the current problem. GMTS then indicates via CRT whether the problem was in fact corrected. If it was not, the student has the opportunity to continue the problem, although GMTS records the fact that the student thought he had found the malfunction when he had not.

YES - NO - Used to answer questions pased in the CRT such as

Is the B+ meter Normal?

Do you wish to continue this problem?

Are you John Smith?

Sample Troubleshooting Problem

The following sample is very typical of the length and complexity of simulated troubleshooting problems. Familiarity of the communications system is not necessary to follow this narrative.

The CRT displays "Problem Number 1" along with the complaint "Cannot Transmit on RPU No. 1." The microfiche projector displays the top level diagram of the UHF Communications System (Figure 5).

1. The user wants to check out unit CU-3866 (11) in the AN/SRC/20. He touches the reference dot, then touches the CU-3866 (no further mention will be made of touching the reference dot, but it is touched for each pictorial diagram). GMTS displays a photograph of the unit, shown in diagram form below.

2. The user sees that the power lamp of the C-3866 is on, and the local-remote switch is set to REMOTE. He switches it to LOCAL by touching LOCAL.

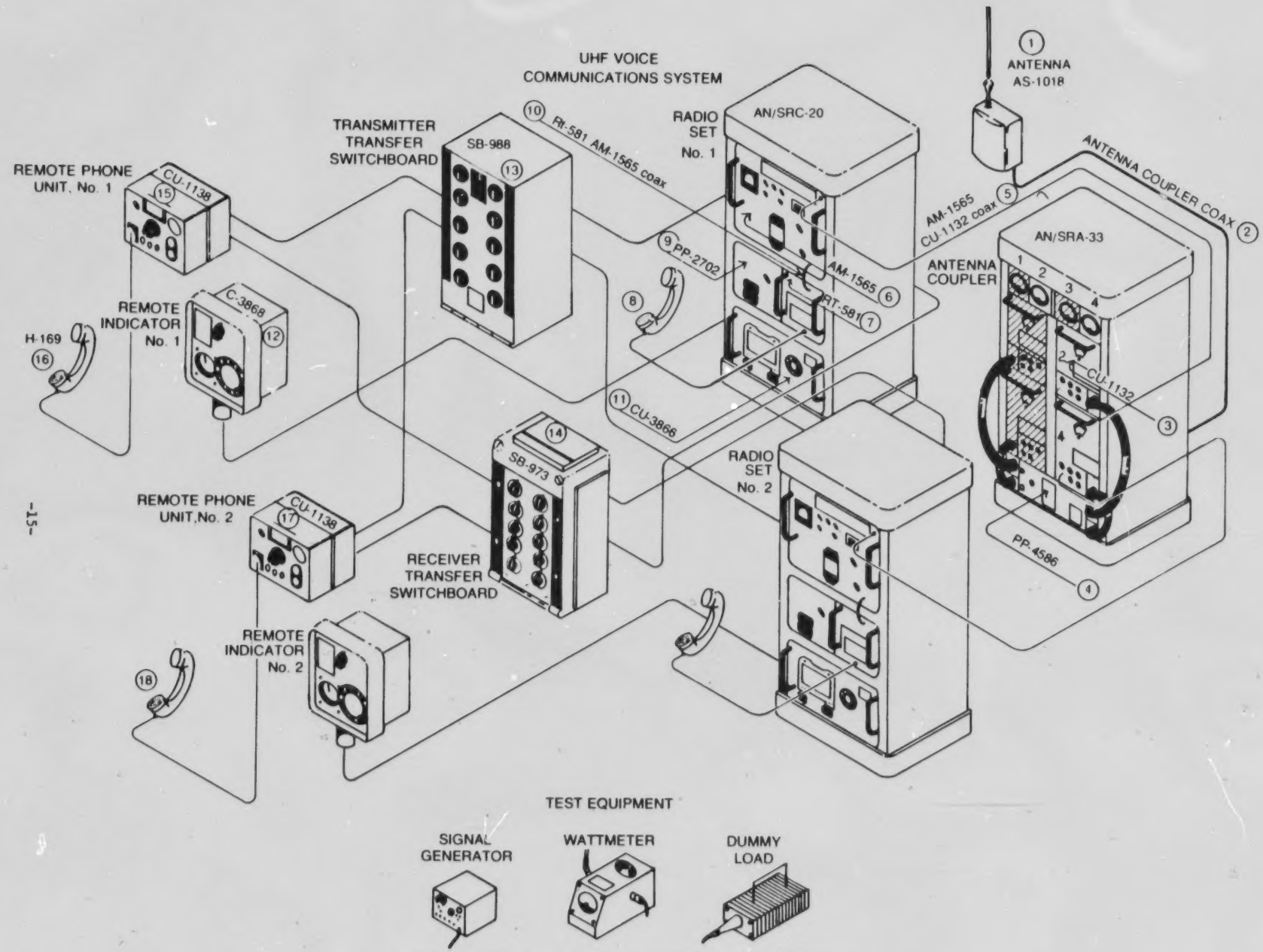


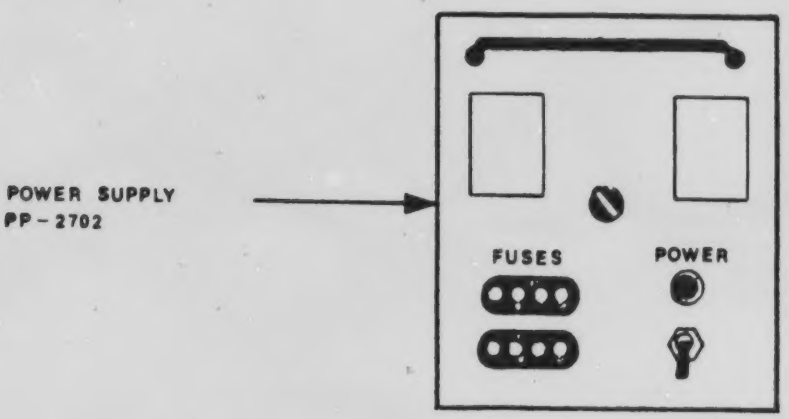
Figure 5. UHF Communications System Top Level Diagram

Since no other settings are desired at this time, he touches [NEW SETTINGS]. Now GMTS displays the CU-3866 in local mode.

3. The user dials channel 1 by touching the 1 in the dial.
4. The user checks fuse F201 by pointing to it. He is shown a picture of a technician testing the fuse with an ohmeter. The CRT displays

   IS THE F201 FUSE NORMAL?

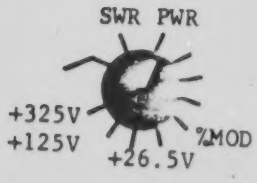
   and the user responds with YES since the ohmeter was indicating continuity.
5. The user touches UP, sees the CU-3866 panel again, touches UP again and sees the top level diagram (the following discussion will abbreviate the details by omitting references to UP, etc.)
6. The PP-2702 is selected and the power lamp is seen to be on



The CRT now asks: "Is the Power Light normal?"

The response [NO] produces "Incorrect, it is normal."

7. The RT-581 unit is selected, and the 125-voltage reading is checked by changing the meter switch from PWR to +125v.



The next image of the RT-581 shows the meter switch set to +125v., and the meter reading in the green band.

8. The student now proceeds to key the transmitter handset, checks the meter reading in this keyed mode, "speaks" into the handset (by touching the mouth piece) "listens" for a reply from another transmitter (by touching the earpiece), and "hears" the reply (by observing the projected image) which says "Hello, we hear your transmission."
9. Subsequent checks (and associated mode changes) verify normal power out of the RT-581, normal SWR (near-zero), and normal % modulation. However, after switching to channel 1 at the RT-581, SWR was observed to be high (abnormal). The user realizes that this "symptom" is a result of mismatching channels, rather than a malfunction, so he returns the RT-581 to remote preset mode. SWR now is normal.
10. The user determines the settings on the AM-1565 linear power amplifier unit and observes a normal high-voltage B+ indication, normal power out, and normal 2500v.
11. The user unkeys the remote handset, keys the AM-1565 test key, and observes normal power out.
12. The user checks the No. 2 meter on the CU-1132 coupler. Power out is normal and reflected power is normal.

13. The AM-1565 is unkeyed and the AN/SRC-20 is put into REMOTE mode. The user checks the power supply PP-4586 in this mode and it is normal.

14. The user selects the wattmeter, "connects" it to the output of the SRA-33 (by touching this alternative in a projected list) and finds both power out and reflected power to be normal.

15. Ultimately the user determines that he can receive only from the No. 1 Remote Phone Unit (RPU) handset, but it does key the C-1138. A radio check then proves that he can receive from the remote-handset, but cannot transmit from the No. 1 RPU-handset. He reviews the troubleshooting tree available in REVIEW and sees that an expert would patch in another RPU and repeat the remote radio check.

16. The user performs the steps recommended by the troubleshooting tree and finds that the radio check message is normal for RPU No. 2, but not RPU No. 1. He suspects either the No. 1 RPU-handset or No. 1 RPU. He touches HELP, selects these two items, and learns that an expert would also suspect these two elements at this stage.

17. Since the student cannot discriminate between the two suspected elements, he arbitrarily replaces the No. 1 RPU. He then repeats the radio checks and finds that they are now normal. He touches DONE and the CRT responds

GOOD. YOU FOUND THE PROBLEM TO BE No. 1 RPU

At this point, the student could proceed directly to another of the 38 available problems, each of which produces all the actual normal

and abnormal indications at the front panels, in all the allowable modes.

GMTS Data Base

The allowable modes are numerous, as seen by the above example which illustrates a small fraction of the modes which could have been entered. The GMTS data base is kept manageable, however, by two devices:

1. Redundant modes are eliminated. For example, the UHF Voice Communications System actually offers 19 preset operating channels, whereas the GMTS data base restricts the student to just two channels (1 and 10). This restriction has virtually no effect upon his opportunity to manipulate the equipment, nor does it limit his troubleshooting strategy, for he can determine if the malfunction affects all (both) channels, just one channel, or neither channel.
2. The data base represents exceptions to standard, normal operation. Normal operation is represented as the indication present at each indicator in each mode. Effects of malfunctions are then described as deviations from the master pattern.

SECTION III. THE FIELD EVALUATION SITE AND SUBJECTS

As a consequence of the cooperation of the Chief of Naval Techical Training, Memphis, and the Naval Schools Command, San Diego, it was possible to install the BTL testbed delivery system at the Advanced Electronics Schools Department Facility, San Diego. There, incoming students waiting to attend Class C school courses served as subjects for the evaluation. Each student was shown how to operate the delivery system, by leading him through the instructions reproduced in the preceding section. This introduction required thirty minutes to an hour, and was done by a BTL field representative. The student then "was on his own" to work his way through thirty-five troubleshooting problems, spending one or two hours per session over a period varying from a few days to over a week, depending on the student's schedule. The BTL field representative was on hand at all times to monitor the equipment and to answer the students questions, but otherwise did not interact with the student. When the student finished the problem set, he was asked to complete a questionnaire soliciting his opinions of the GMTS, and his comments and suggestions for improvements.

The data-collection proceeded satisfactorily, although the availability of only one delivery system necessarily prolonged the period required to run twenty subjects for the ten hours or so of student-instructional system contact time required to get through the problem set. The delivery system hardware functioned better than expected, considering its doubtful parentage. The few times it was down were due

to floppy-disk drive problems. However, the delivery system was strictly an R&D testbed, in no sense product or reliability engineered to function for prolonged periods in a "school house" equipment.

Results

The principal results are summarized in Figures 12 and 13, and in the observed frequencies of responses to the questionnaire.

It is apparent from Figure 12 that practice with the GMTS had the desired effect of increasing fluency of troubleshooting performance. Mean times to localize a malfunction were reduced by a factor of two, and standard deviations by a factor of five. This means that the practice resulted in a "standard product;" all students learned to troubleshoot the UHF communications system reliably and quickly. They evidently acquired representational and procedural knowledge that allowed them to reduce the uncertainty (from an information theory standpoint) in a problem to near zero. Similar trends were noted for the average extra units replaced per problem.

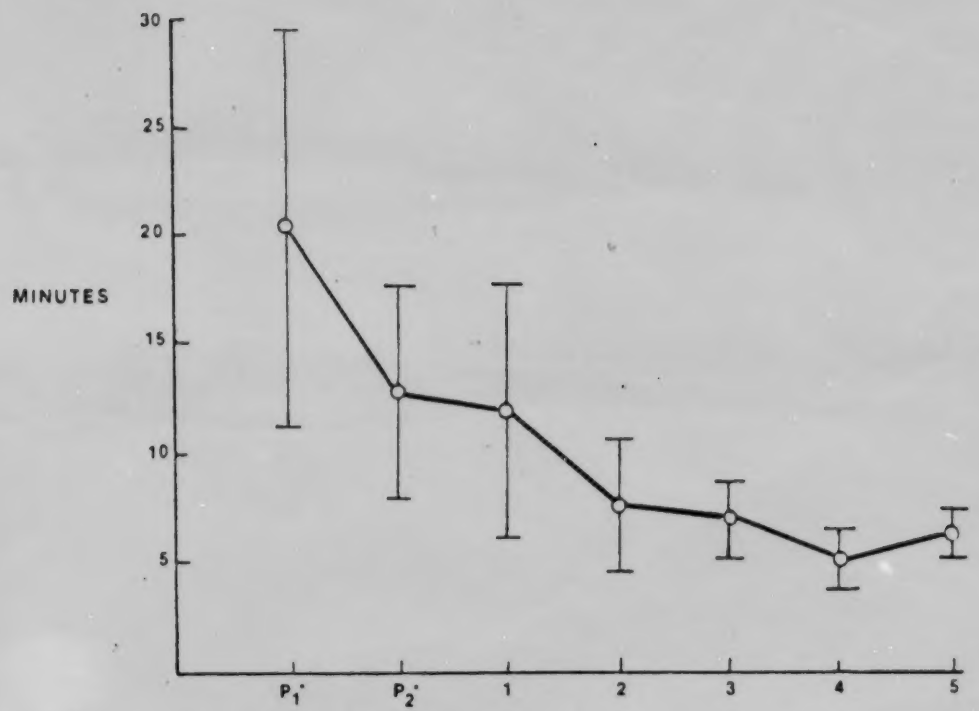


Figure 6. Average Solution Times per Problem Within Blocks
(Means and Standard Deviations)
*Help Function Available.

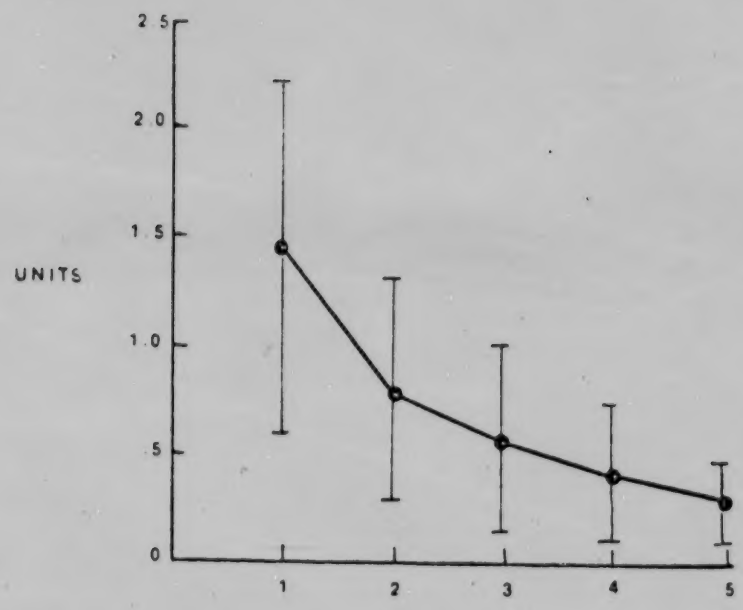


Figure 7. Average Extra Units Replaced per Problem Within Blocks (Means and Standard Deviations)

Table 1

Summary of Responses to Thirteen
Attitude Questionnaire Items
(N = 16)

4.70	Very Favorable
5.08	Favorable
1.78	Neutral
.57	Unfavorable
.00	Very Unfavorable

Attitude Questionnaire Means
13 Questions, 16 Subjects

Table 2

Means of Responses to the
Following Question:
(N = 16)

How would you divide 10 hours to practice system trouble-shooting between GMTS and actual COMM system?

GMTS : 5.2 hours

Actual: 4.8 hours

SECTION IV. CONCLUSIONS

The viability of the GMTS concept has been partially demonstrated. As implemented in the BTL testbed, it changed students troubleshooting performance in desirable directions, and it was favorably viewed by the students as being a useful adjunct to their technical training. However, it is important to get additional information about the transfer of representational and procedural knowledge acquired from the GMTS to working on the actual equipment. There are many issues of this nature that need to be explored. Roscoe's (1971) Transfer Effectiveness Ratio was an early formulation of the non-linear transfer rate function, based on time. Current emphasis on cost-savings and cost-effectivess were recognized by Crawford, Hurlock, and Rogo (1978) in their analysis of the effectiveness of a computer graphics-based simulator versus a traditional 3D simulator for ASW tactical training.

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Crawford, A. M., Hurlock, R. E., and Rogo, T. P. Computer-Based Graphic Simulations for Tactical Communications Training. NPRDC, TR 77-42, AD-A044-837.

Jerison, Harry J., Evolution of the brain and intelligence, New York, Academic Press, 1973.

Roscoe, Stanley N., Incremental transfer effectiveness, Human Factors, 1971, 13(6), 561-567.

APPENDIX A

UHF VOICE COMMUNICATIONS SYSTEM

TECHNICAL MANUAL

TABLE OF CONTENTS

TITLE	PAGE
GMTS Communications Configuration Introduction	32
Communications Configuration Troubleshooting	36
Radio Set AN/SRC-20	38
Radio Frequency Amplifier AM-1565/URC	39
Radio Set AN/URC-9	40
Receiver-Transmitter RT-581/URC-9	40
Power Supply PP-2702/URC-9	41
Radio Set Control C-3866/SRC	41
Radio Set AN/SRC-20 Turn-on Procedure	42
Radio Set AN/SRC-20 Squelch Function	45
Radio Set AN/SRC-20 LOCAL-REMOTE Operation	47
Radio Set AN/SRC-20 Normal Mode Keying	48
Radio Set AN/SRC-20 Intercabling	50
Radio Set AN/SRC-20 AC Power Distribution	51
Radio Set AN/SRC-20 Description of Controls and Normal Meter Indications:	
Radio Frequency Amplifier AM-1565	52
Radio Set AN/URC-9	54
Radio Set Control C-1138/UR	56
Indicator Control C-3868/SRC	59
Transmitter Transfer Switchboard SB-988/SRT	61

TITLE PAGE

Receiver Transfer Switchboard 65

Antenna Coupler Group AN/SRA-33 69

Multimeter AN/PSM-4 75

Wattmeter AN/URM-120 76

Dummy Load DA-274 77

LIST OF ILLUSTRATIONS

FIGURE #	TITLE	PAGE
0-1	Communication System Block Diagram	33
0-2	GMTS Voice Communication System	35
1-1	Radio Set AN/SRC-20 Pictorial	38
1-2	Radio Frequency Amplifier AM-1565/URC Pictorial	39
1-3	Radio Set AN/URC-9 Pictorial	40
1-4	Power Supply PP 2702 Pictorial	41
1-5	Radio Set Control C-3866/SRC Pictorial	41
1-6	Radio Set AN/URC-9 Pictorial	42
1-7	Radio Frequency Amplifier AM-1565/URC Pictorial	43
1-8	Radio Set Control C-3866/SRC Pictorial	44
1-9	Transceiver RT-581 Squelch Function Pictorial	45
1-10	Radio Set Control C-3866 Squelch Function Pictorial	46
1-11	SRC-20 Normal Mode Keying Pictorial	49
1-12	Radio Set AN/SRC-20 Intercabling	50
1-13	Radio Set AN/SRC-20 AC Power Distribution	51
1-14	RF Amplifier AM-1565 Meter	53
1-15	Radio Set AN/URC-9 Meter	55
2-1	Radio Set Control C-1138/UR	56
2-2	Audio and Keying Interconnection C-1138 & SRC-20	58
3-1	Indicator Control C-3868/SRC	59
3-2	Indicator Control Remote Preset Channel Interconnection	60
4-1	Transmitter Transfer Switchboard Interconnection	61

FIGURE #	TITLE	PAGE
4-2	Transmitter Transfer Switchboard SB-988 Wipers	62
4-3	Transmitter Transfer Switchboard SB-988 Switch Positions . .	63
4-4	Switchboard SB-988 12-wire Interconnection	64
5-1	Receiver Transfer Switchboard Interconnections	65
5-2	Receiver Transfer Switchboard SB-988 Wipers	66
5-3	Receiver Transfer Switchboard SB-988 Switch Positions . . .	67
5-4	Switchboard SB-973/SRR Wiring	68
6-1	Coupler Group AN/SRA-33	69
6-2	Coupler Unit CU-1132	70
6-3	Coupler Combiner Network	71
6-4	Power Supply C-4586/SRA-33	72
6-5	Electronic Equipment Cabinet CY-3852/SRA-33	74
7-1	Multimeter AN/PSM-4	75
8-1	Wattmeter AN/URM-120	76
9-1	Dummy Load DA-274	77

GENERALIZED MAINTENANCE TRAINER

COMMUNICATIONS SYSTEM CONFIGURATION

INTRODUCTION

Fast, reliable communications is essential for the operation of a widely dispersed Navy organization. Navy ships must communicate with distant shore stations along with close-in and medium-distant ships and aircraft. To provide ships with these capabilities, a variety of communication equipments are required. Rigid shipboard space and weight requirements demand that these equipments not only be compatible, but flexible.

A communications system consists of all the electronic and mechanical equipments used for the transmission and reception of radio messages. (See Figure 0-1). Interconnections enable the selective switching of physically separated equipments into many different and often complex configurations. A communications configuration is the functional arrangement of electronic/mechanical equipments used in the transmission and reception of radio messages. The two main configurations are voice (telephone) and teletypewriter. A minor configuration, for instance, is facsimile which is used to transmit or receive copies of pictures. For communications security, crypto (Secure) equipments may be used to encode messages for transmission and decode encrypted messages on reception.

Communications play such a vital role in today's Navy, the technician must be able to isolate system malfunctions quickly and restore the system to full operation in a minimum of time.

COMMUNICATION SYSTEM BLOCK DIAGRAM

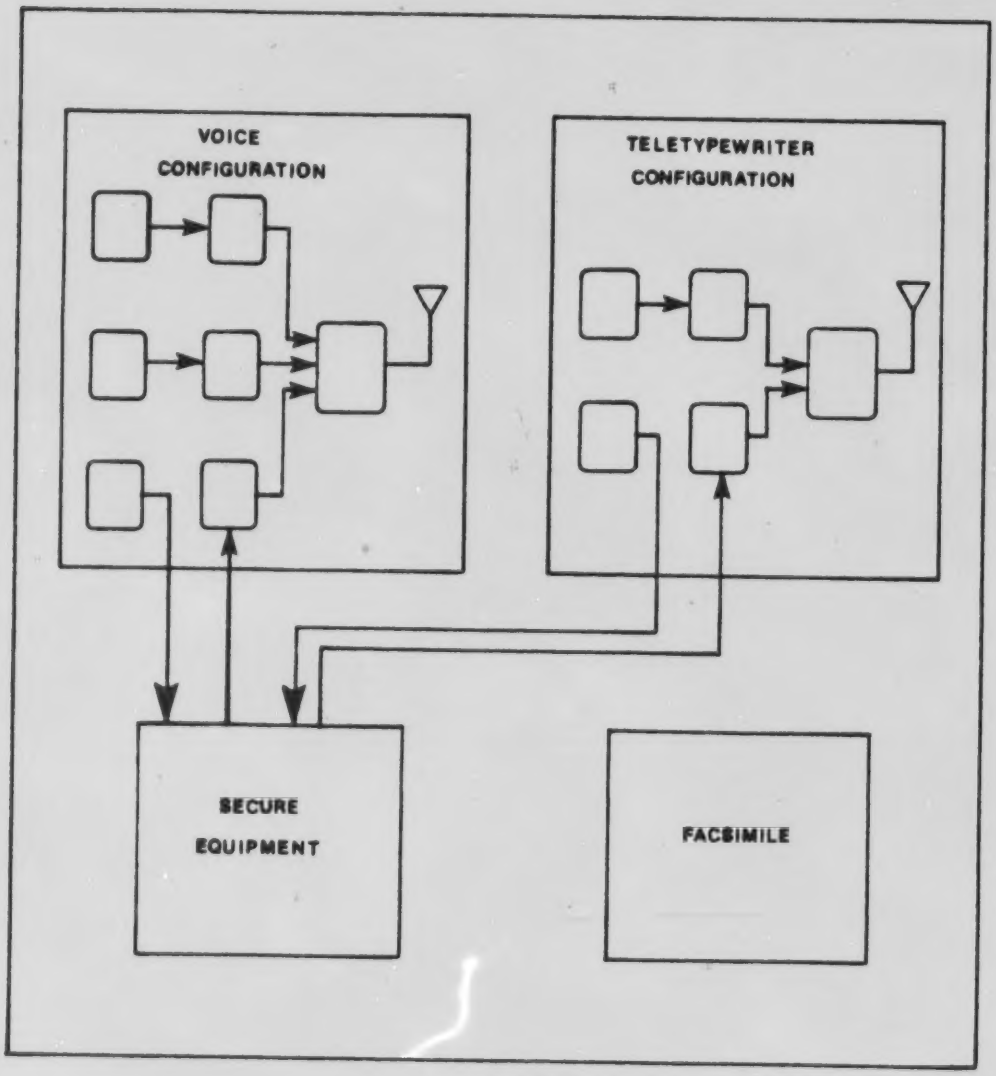


FIGURE 0-1

The purpose of GMTS is to provide system level troubleshooting for a basic communications system configuration. UHF voice is one of the communications configurations that can be simulated with GMTS. A basic shipboard UHF voice configuration is shown in (Figure 0-2). The equipments used in the configuration are discussed briefly in this section.

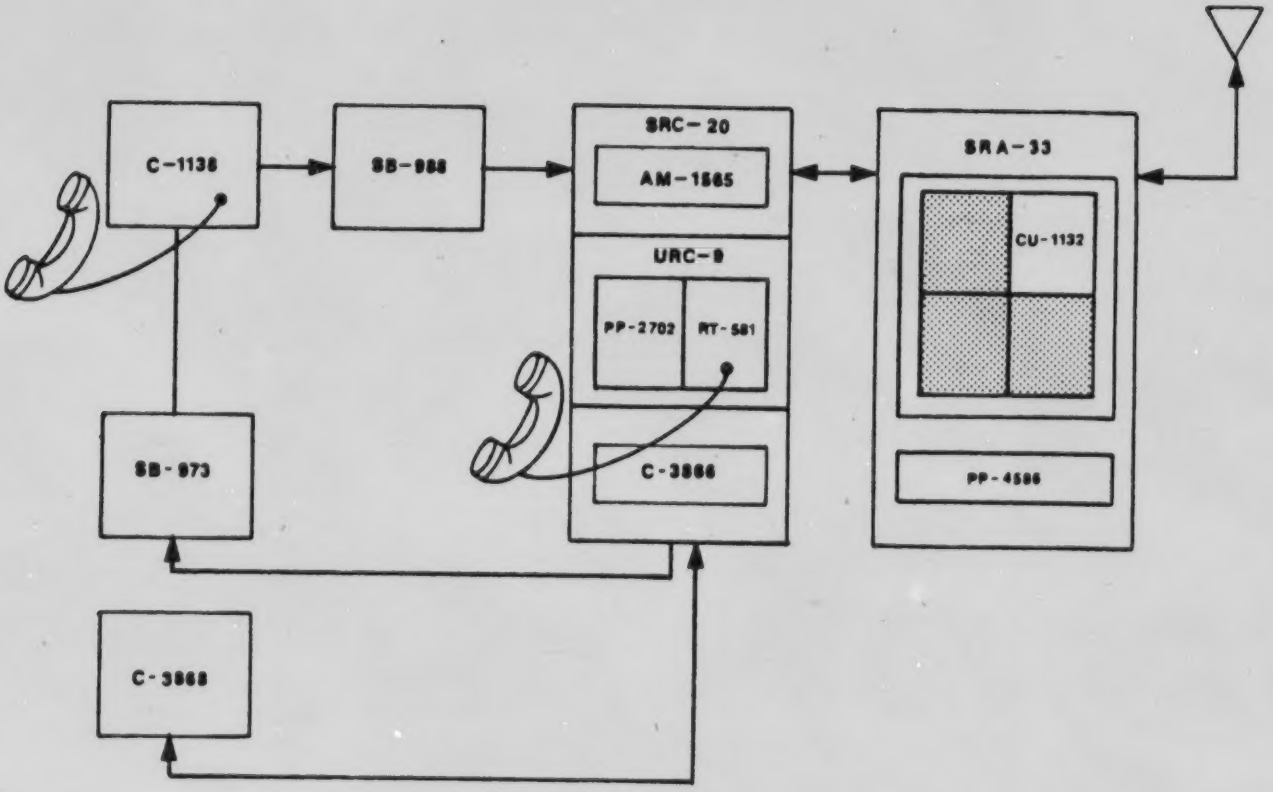
The radio set AN/SRC-20 is the heart of the UHF voice communications configuration. It is made up of three major units: Radio Set (AN/URC-9), Radio Frequency Amplifier (AM-1565) and Radio Set Control (C-3866). The Radio Set (AN/URC-9) has two units: the transceiver (RT-581) which combines the functions of both transmitter and receiver in one unit, and the power supply (PP-2702) which provides DC operating voltages for the (RT-581) transceiver. The radio frequency amplifier (AM-1565) is a UHF linear power amplifier which amplifies the RF output of the RT-581.

The antenna coupler group (AN/SRA-33) is composed of four individual coupler units with each coupler providing isolation for one AN/SRC-20 radio set, however, the outputs of the four coupler units are coordinated and tied to the same common antenna.

The radio set control unit (C-3866) provides for control of the primary AC power for the AN/SRC-20, local or remote phone operation and locally changing preset frequency channels on the AN/SRC-20 and AN/SRA-33.

The remote phone unit (RPU) (C-1138) allows remote operation of a radio set for voice communications.

The indicator control unit (C-3868) has two functions, a telephone-type dial for remotely changing preset channels and an indicator that points to the preset channel number being used.



GMTS VOICE COMMUNICATION SYSTEM

FIGURE 0-2

COMMUNICATIONS CONFIGURATION TROUBLESHOOTING

The equipments used in a communications configuration occasionally fail or are operated improperly, causing the loss of communications on one or possibly several circuits. When a loss of communications is reported or discovered, the technician should proceed logically and rapidly to isolate the malfunction or operator error to a specific equipment. In order to isolate a configuration problem, the technician should use essentially the same methodology as in troubleshooting an equipment malfunction. A repetitive "divide and conquer" strategy is used. Initially divide the configuration in half, determine which half is suspect, then divide the suspected section in half and repeat the process until the malfunction is isolated to the faulty equipment. Built-in checkpoints such as meters, indicator lamps, switch settings, etc. should be observed and used. The proper use of the checkpoints will allow the technician to determine whether test signals are normal or abnormal. (See Table 0-1). Normally, operating equipment can be substituted for suspect equipment and the configuration checked for normal operation. Normal operation of the configuration, as in successfully conducting a radio check, indicates the malfunction has been corrected.

Table O-1

EQUIPMENT/COAX SUBSTITUTION LIST & EXPECTED SIGNAL(S)

GMTS #	Equipment Title	Expected Signal(s)
1	Antenna AS-1018	UHF Mod/Unmod, (Xmit/Rec)
2	Coax (CU-1132 to Antenna)	UHF Mod/Unmod, (Xmit/Rec)
3	Antenna Coupler CU-1132	UHF Mod/Unmod, (Xmit/Rec)
4	Power Supply PP-4586	DC Power for SRA-33
5	Coax (CU-1132 to AM-1565)	UHF Mod/Unmod, (Xmit/Rec)
6	RF Amplifier AM-1565	UHF Mod/Unmod, (Xmit/Rec) Audio (Xmit/Rec) Xmit Control, Chan Select
7	Transceiver RT-581	GMTS #1-18
8	Handset H-169	Audio (Xmit/Rec), Xmitr Keying
9	Power Supply PP-2702	DC Power for RT-581
10	Coax (AM-1565-RT-581)	UHF Mod/Unmod (Xmit/Rec)
11	Radio Set Control C-3866	Audio (Xmit/Rec), Xmit Control, Chan Sel, Synchro
12	Remote Indicator/ #1 C-3868	Chan Select, Synchro
13	Switchboard SB-988	Audio (Xmit), Xmit Control, Xmitr Keying
14	Switchboard SB-973	Audio (Rec)
15	RPU #1 C-1138	Audio (Xmit/Rec), Xmit Control, Xmtr Keying
16	Handset H-169 (RPU #1)	Audio (Xmit/Rec), Xmitr Keying
17	RPU #2 C-1138	Same as RPU #1 (15) when selected by Transmitter Tran Switchboard (13)
18	Remote Indicator #2 C-3868	Same as Remote Indicator #1 when selected by Receiver Tran Switchboard (14)

RADIO SET AN/SRC-20

The Radio Set An/SRC-20 is used for shipboard or shore, amplitude-modulated, radio voice communications. It operates in the UHF radio frequency range. It provides simplex transmission and reception. That is, it can transmit or receive, but not both at the same time. The SRC-20 frequency range is 225.0 to 399.9 MHz. It has 1750 voice channels, nineteen of these may be preset and selected locally or remotely.

The Radio Set An/SRC-20 is composed of three major units as shown in Figure 1-1.

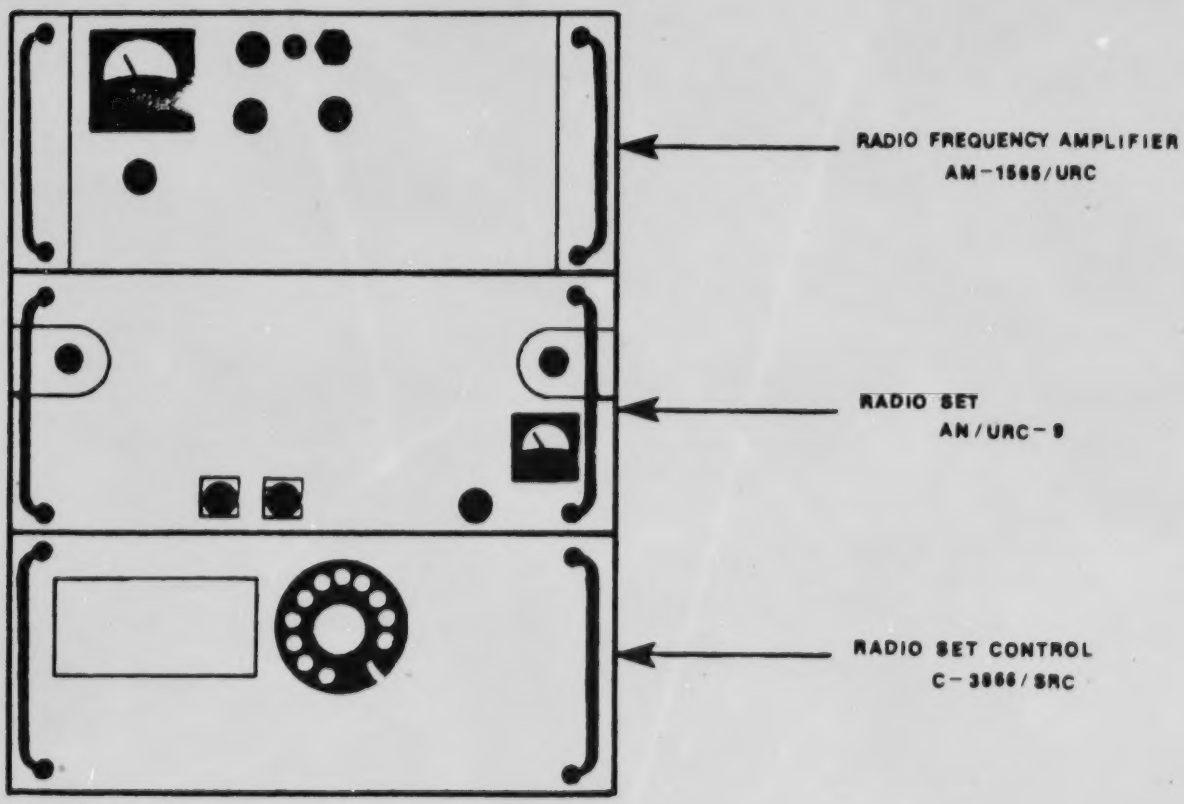


FIGURE 1-1

The Radio Frequency Amplifier AM-1565/URC is a linear RF power amplifier. It amplifies the 10 to 16 watt RF output from the Radio Set AN/URC-9 to recommended output of 100 watts. The RF Amplifier AM-1565 is continuously tunable over its frequency spectrum. Nineteen of its transmit frequencies may be preset for remote or local selection. These are called preset channels. It has its own power supply, and is a completely contained unit.

AM-1565

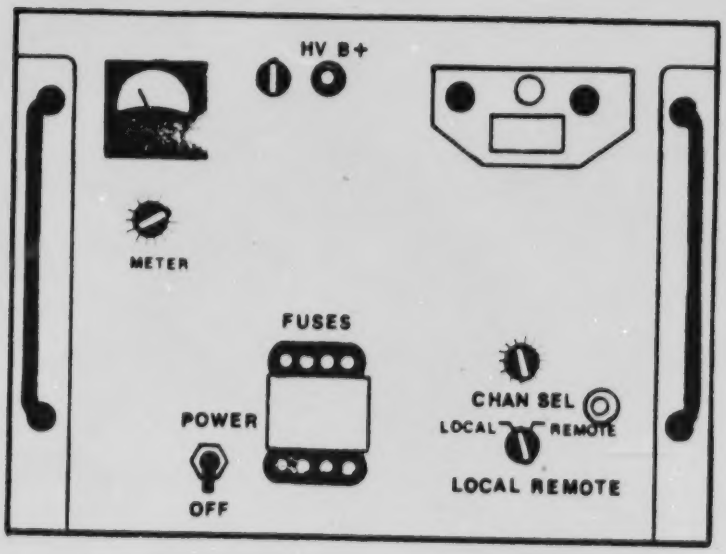


FIGURE 1-2

The Radio Set AN/URC-9 is made up of two units which are housed in the same case:

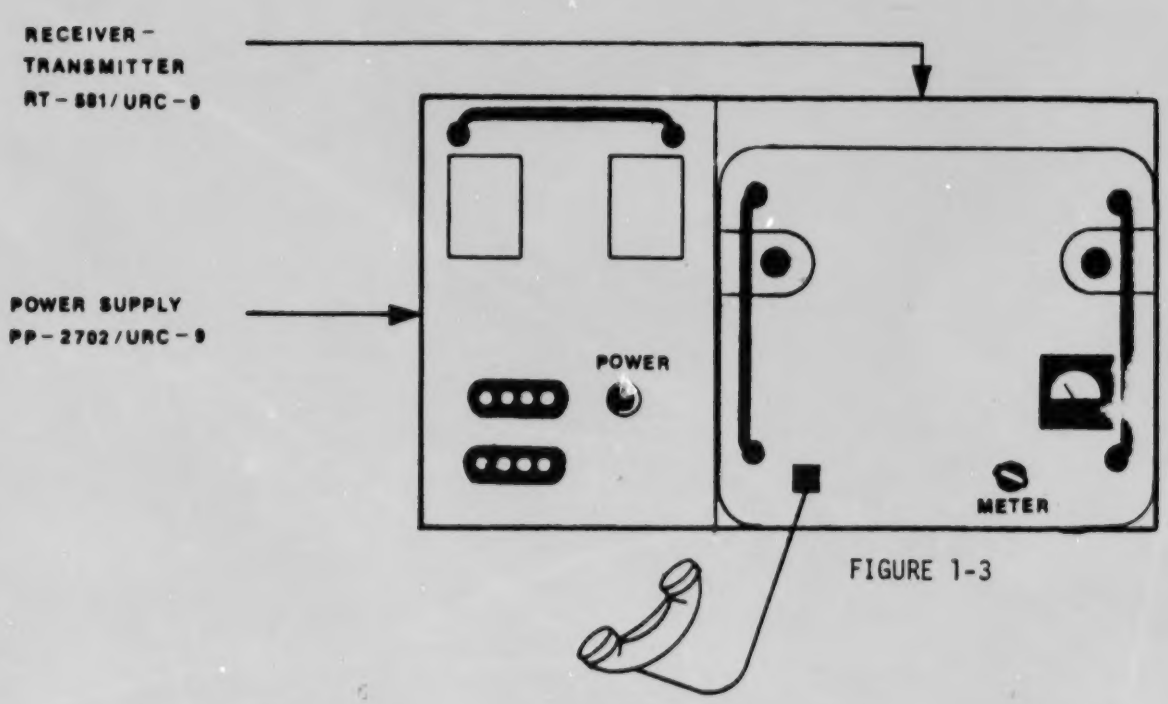


FIGURE 1-3

The Receiver-Transmitter RT-581 is a transceiver, which operates as a superheterodyne receiver during standby operation. When the microphone push-to-talk switch is closed, the TR/relays convert the RT-581 to a transmitter. Many of the same IF, RF, and audio circuits are used during both transmission and reception. Nineteen of the RT-581's transmit/receive frequencies may be preset and selected locally or remotely.

The Power Supply PP2702 provides most of the operating voltages and fusing required by the URC-9. It operates on either 115 or 230 volts a.c.

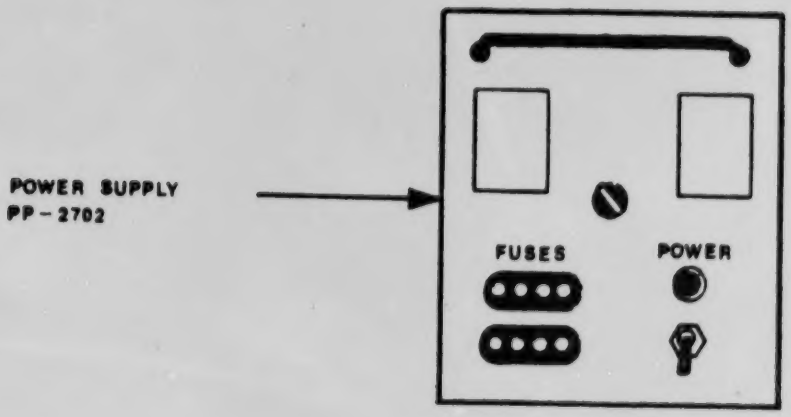


FIGURE 1-4

The Radio Set Control C-3866/SRC is a control unit which permits local or remote operation of the RT-581 and the AM-1565. All primary power for the URC-9 and the AM-1565 is routed through the Radio Set Control C-3866. A telephone-type dial is used to select any one of the 19 preset channels in the AN/SRC-20. The C-3866 provides for the setting of the squelch level for each of these channels.

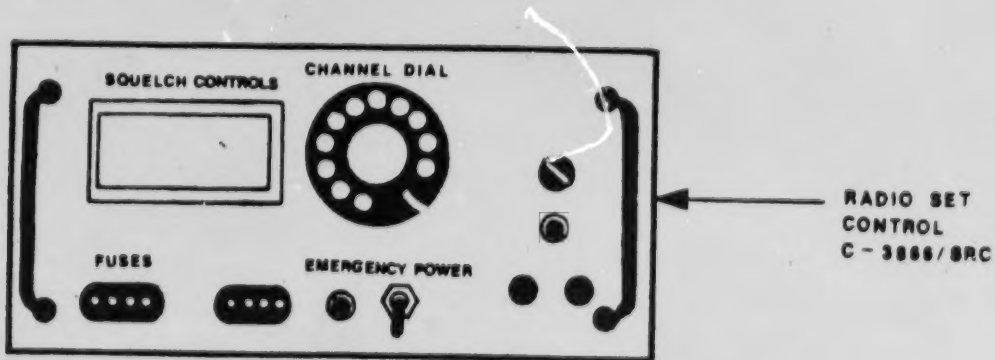


FIGURE 1-5

RADIO SET AN/SRC-20 TURN-ON PROCEDURE

RADIO SET AN/URC-9 Initial Conditions

Normal (NOR) mode of operation, switches should be placed as follows:

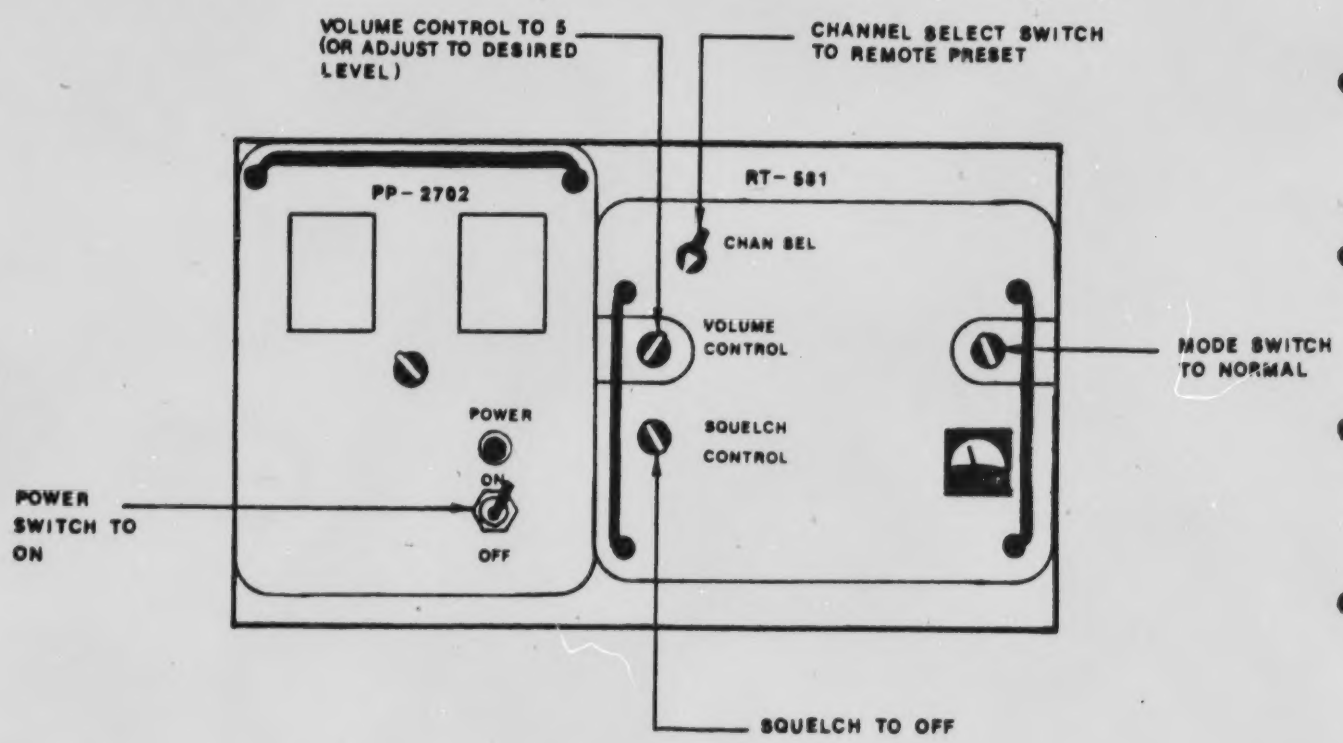


FIGURE 1-6

RADIO FREQUENCY AMPLIFIER AM-1565/URC Initial Conditions

Normal (NOR) mode of operation, switches should be placed as follows:

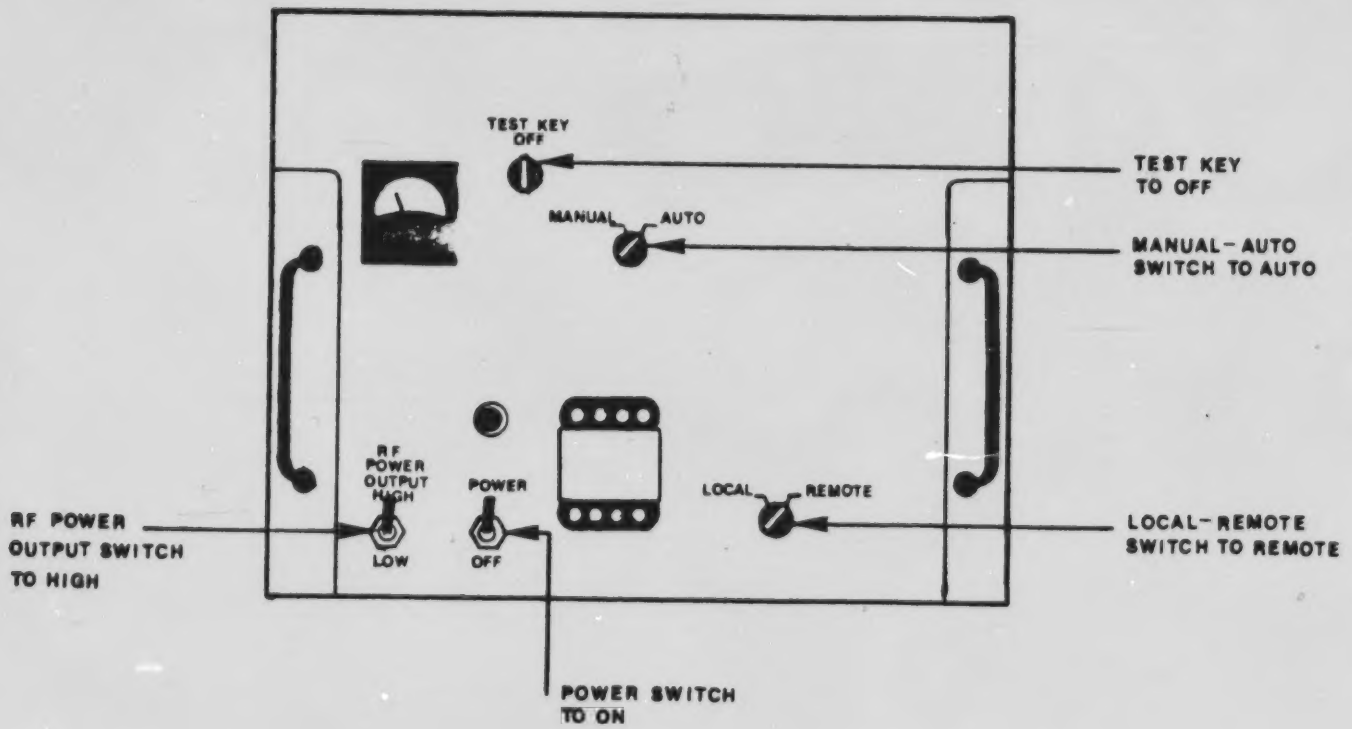


FIGURE 1-7

RADIO SET CONTROL C-3866/SRC Initial Conditions

Normal (NOR) mode of operation, switches should be placed as follows:

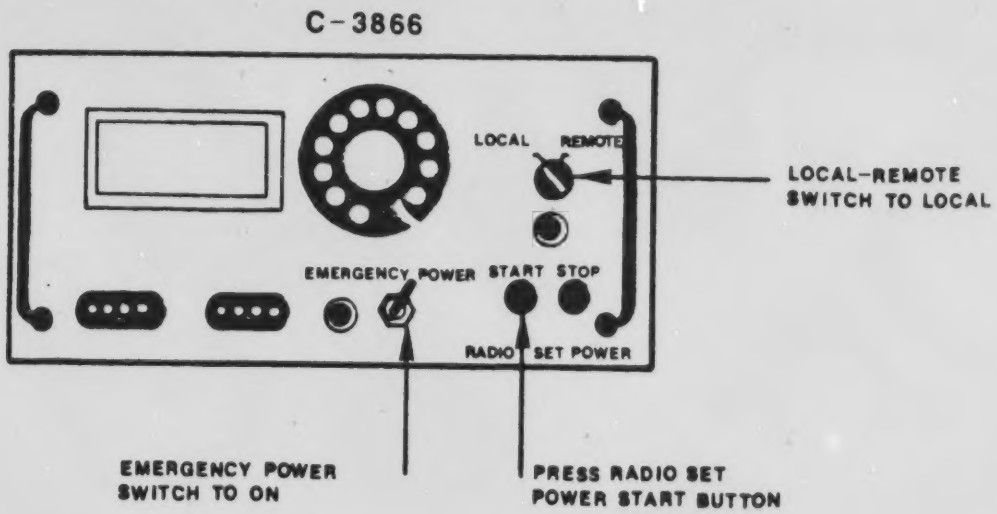


FIGURE 1-8

The equipment is now energized. The Power indicator lamps on the C-3866, URC-9, and AM-1565 should be illuminated. After a one minute time delay in the AM-1565, the equipment is ready for operation. An RF preset channel may now be selected at the C-3866 by using the telephone-type dial switch. This sets the transmitter and receiver frequency of the RT-581 and the power amplifier frequency of the AM-1565.

Remote selection of the preset channels is accomplished by setting the LOCAL-REMOTE switch on the C-3866 to REMOTE and dialing from the remote station (Remote Indicator C-3868/SRC). Up to nineteen different frequencies may be preselected.

RADIO SET AN/SRC-20 MODES OF OPERATION

Although the SRC-20 has four modes of operation, only the NOR (normal)

mode is utilized with GMTS. This mode is selected at the front panel of the URC-9 with the MODE switch set to NOR and the PLAIN-BROADBAND switch, located on the rear of the URC-9 set to the PLAIN position. During the normal mode the Radio Set An/URC-9 operates as a transceiver for voice communications. A local or remote push-to-talk microphone provides voice modulation and keying of the transmitter.

RADIO SET AN/SRC-20 SQUELCH FUNCTION

Squelch circuits are used in the SRC-20. These circuits are designed to eliminate noise in the speaker or headset when the received RF carrier signal is absent or below a predetermined level. If the squelch circuit is set too high, normal received signals may be eliminated. If the squelch circuit is set too low, receiver noise (hiss/crackle) will be present when no signal is being received. The CALL LIGHT lamp on the URC-9, RT-581 lights when the squelch circuit is disabled or when a signal of sufficient strength overrides the squelch level set.

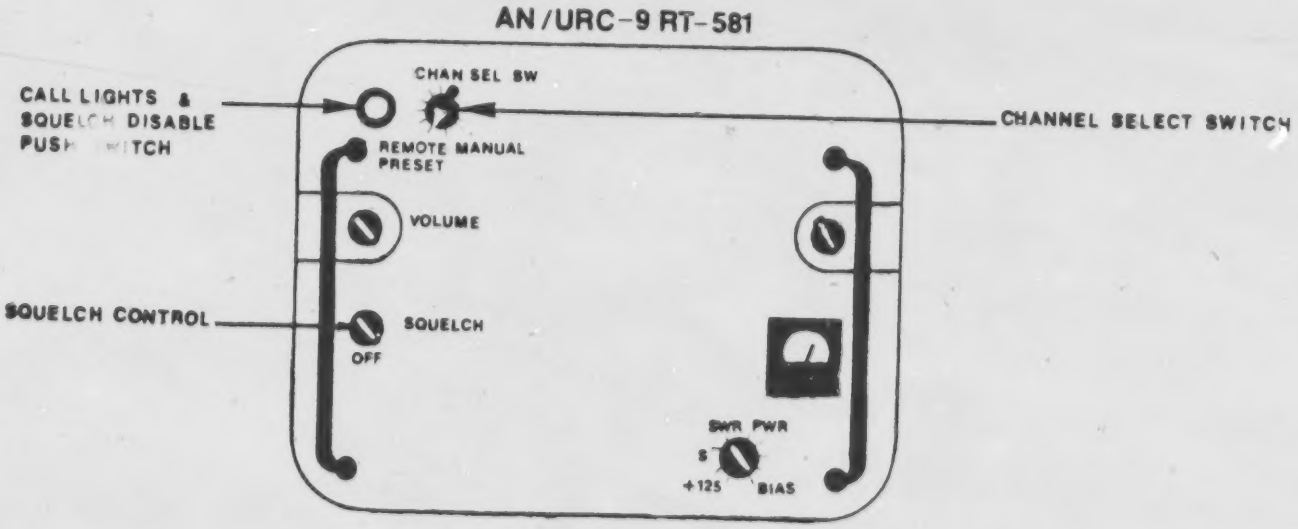


FIGURE 1-9

The Radio Set An/SRC-20 squelch function may be controlled at the RT-581 when its CHAN SEL switch is set to one of the 19 preset channels, or to MANUAL. The SQUELCH control on the RT-581 then controls the squelch level.

The squelch function may also be controlled at the Radio Set Control C-3866/SRC when the RT-581 CHAN SEL switch is set to the REMOTE PRESET position, and the RF Amplifier AM-1565 LOCAL-REMOTE switch is set to REMOTE. The C-3866 contains 19 squelch potentiometers (pot) see Figure 1-10. One pot is assigned to each RF preset channel, and each pot is individually adjusted for the desired squelch level. Squelch Pot #1 controls RF Preset Channel #1, Squelch Pot #2 controls RF Preset Channel #2, etc. There is only one squelch pot for each preset channel.

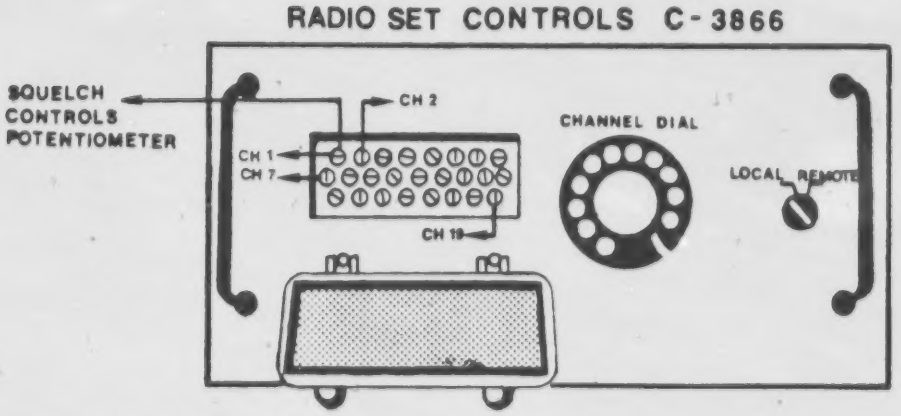


FIGURE 1-10

RADIO SET AN/SRC-20 LOCAL-REMOTE OPERATION

LOCAL CONTROL SRC-20: The SRC-20 is set up with the initial conditions shown on Pages 1-5 to 1-8. Local control is accomplished at the Radio Set Control C-3866. The 19 preset channels for the URC-9 (RT-581), and the RF Amplifier AM-1565 are dialed at the C-3866. Voice modulation and keying of the RT-581 and the AM-1565 are accomplished at the RT-581 with a push-to-talk microphone. Squelch for each of the 19 preset channels is controlled by the squelch pots on the C-3866. The VOLUME Control on the RT-581 sets the level of audio to the headset.

REMOTE CONTROL SRC-20: Normally the SRC-20 is operated remotely in conjunction with the Radio Set Control (RPU) C-1138/UR, and the Indicator Control C-3868/UR The Radio Set Control C-3866 LOCAL-REMOTE Switch is placed in the REMOTE position. In this setting the Indicator Control C-3868/UR telephone-type dial is used to select one of the 19 preset channels. Transmit/receive frequencies for the RT-581 and the AM-1565 are dialed at the Indicator Control C-3868. Squelch for each of the channels is controlled at the C-3866. Voice Modulation and keying of the RT-581 and the AM-1565 is accomplished at the Radio Set Control (RPU) C-1138. The EARPHONE LEVEL pot on the C-1138 controls the audio level to the headset.

RADIO SET AN/SRC-20 NORMAL MODE KEYING

The RF carrier of the AN/URC-9 RT-581 Transceiver may be keyed (turned-on) in several ways. See Figure 1-11. With the URC-9 MODE Switch set to NOR, the RT-581 Transceiver may be keyed at the URC-9 with the microphone push-to-talk switch. With the RF Amplifier AM-1565, and the Radio Set Control C-3866/SRC LOCAL-REMOTE Switches set to REMOTE, the microphone push-to-talk switch of the remote Radio Set Control C-1138 (RPU) will key the Transceiver. Note that the Antenna Coupler AN/SRA-33 can disable the remote keying. This occurs when the antenna coupler is tuning, or when another transmitter-antenna coupler combination is set to a frequency within five megacycles and keyed to transmit. Transmitter keying may also be accomplished at the RF Amplifier AM-1565 for test purposes by setting the TEST KEY to ON or LOCK ON.

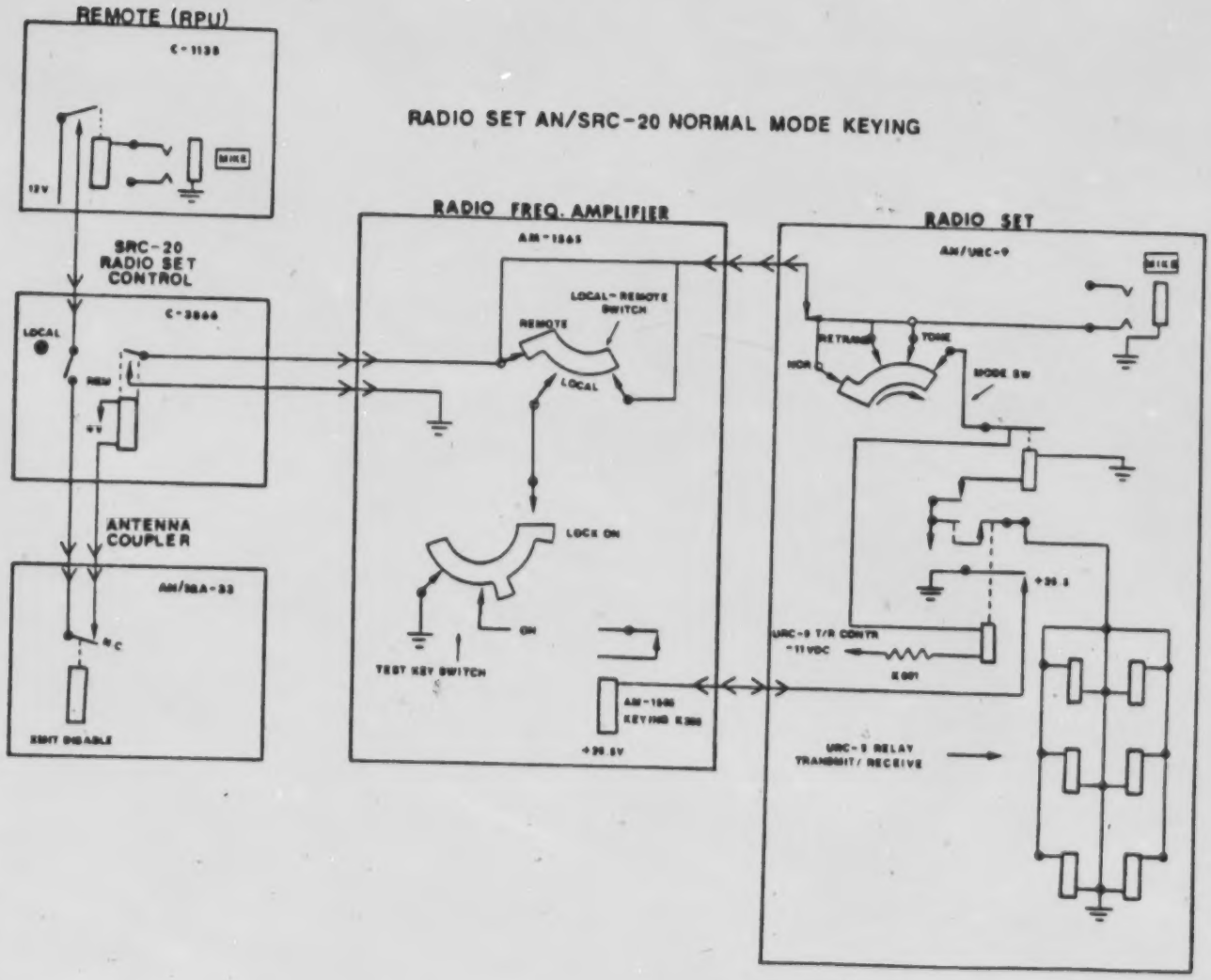


Figure 1-11

59

RADIO SET AN/SRC-20 INTERCABLING:

The SRC-20 intercabling for the power, audio, press-to-talk, and RF (coax) interconnections is shown below. Also included is the Antenna Coupler Group AN/SRA-33, the SB-973 switchboard and the remote units.

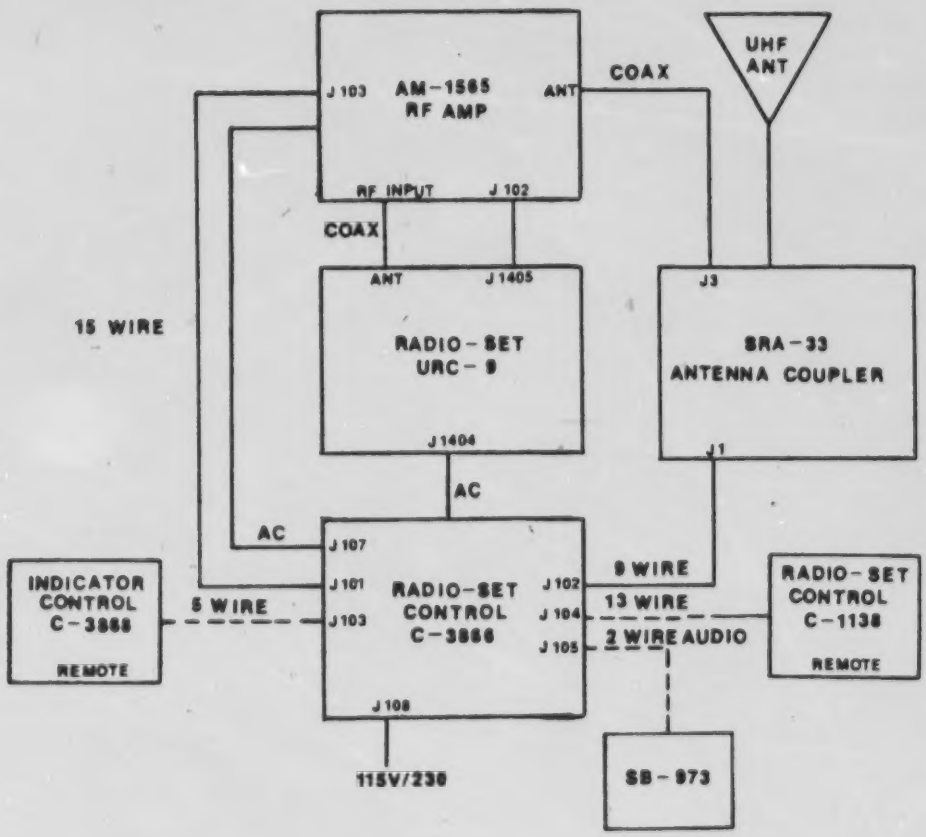


FIGURE 1-12

RADIO SET AN/SRC-20 AC POWER DISTRIBUTION

The AC power (115/230v) is applied to the Radio Set AN/URC-9 and the RF Amplifier AM-1565 through the EMERGENCY POWER Switch and the fusing of the Radio Set Control C-3866/SRC. The URC-9 and the AM-1565 have their own POWER (ON)/OFF switches as well as additional fusing. In normal operation these switches are left in the POWER (on) position, and the equipment is turned on and off using the START-STOP pushbuttons on the Radio Set Control C-3866. The start switch has holding contacts which keep the relay power supply energized until the STOP pushbutton is pressed.

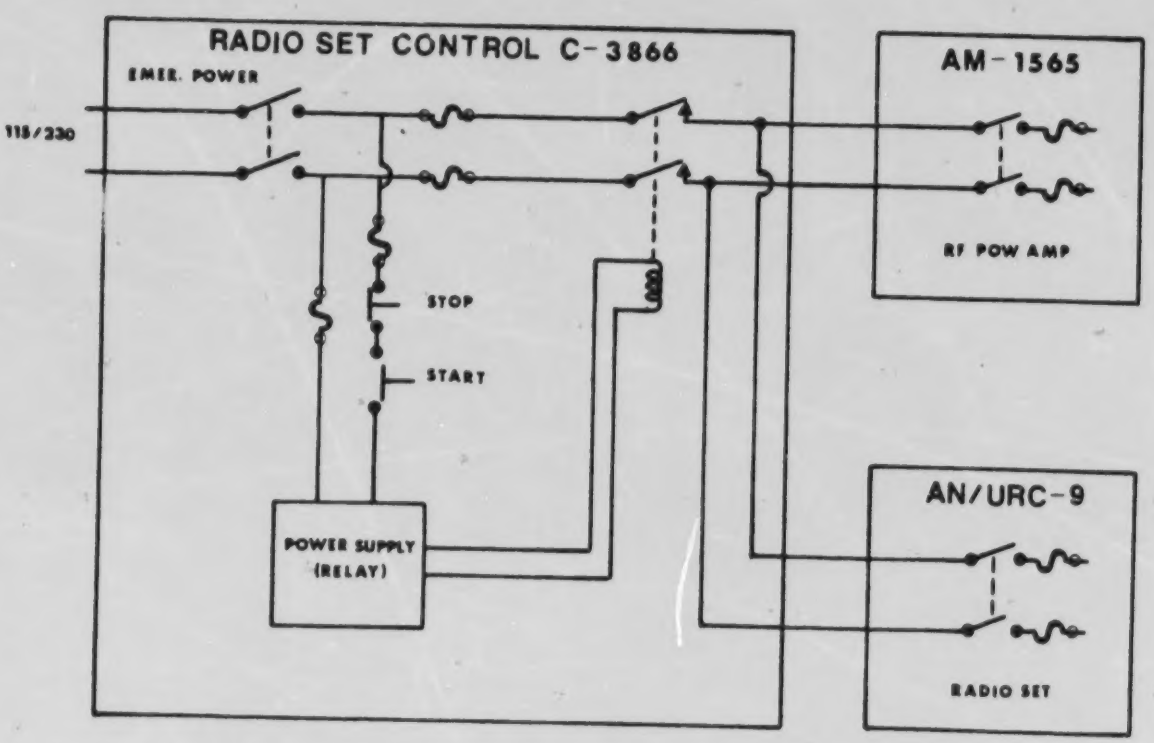


FIGURE 1-13

RADIO SET AN/SRC-20 DESCRIPTION of CONTROLS &
NORMAL METER INDICATIONS

RADIO FREQUENCY AMPLIFIER AM 1565/URC:

POWER Switch: Controls primary input power

POWER Indicator: Indicates primary power has been applied

DIMMER Control: Controls brilliance of front panel lamps

CAUTION INDICATOR: Indicates when high-voltage protect is disabled

TEST KEY Switch:

ON--keys AN/SRC-20 to transmit for test purposes

OFF--AN/SRC-20 not keyed at AM 1565

LOCK ON--Locks AN/SRC-20 in continuous transmit condition for test purposes

HV B+ Indicator: Indicates that high-voltage B+ is turned on; light when AN/SRC-20 is keyed

EXCITATION Controls:

LOW-HIGH--Provides manual low or high excitation adjustment (MANUAL-AUTO Switch in MANUAL)

MANUAL-AUTO--Provides manual or automatic excitation control

LOCAL-REMOTE Switch: Allows selection of local or remote control of desired frequency channels

CHAN SEL Switch: Provides selection of preset or manual channels in local operation

MANUAL TUNING Control: Provides manual frequency control when the CHAN SEL Switch is in MANUAL

FREQ-MC Dial: Gives approximate indication of frequency in MHz

LOG-LOG Dial: Indicates log of frequency to permit preparation of Log-vs-Frequency Chart

RF POWER OUTPUT Switch:

HIGH--Couples 100-watt (average carrier) output of AM-1565 to the antenna or coupler

LOW--Couples 16-watt of output of AN/URC-9 directly to the antenna or the coupler bypassing the AM-1565

RADIO FREQUENCY AMPLIFIER AM-1565/URC (continued)

Meter & METER Switch: Meter monitors any one of 11 functions selected by the METER Switch

METER POSITION:	FUNCTION:	TRANSMITTER KEYED/UNKEYED:	NORMAL INDICATIONS:
HV	+1800V dc	Keyed	Black Scale 72
Bias 1	-60V dc to V201	Unkeyed	Black Scale 50
Bias 2	-60V dc to V202	Unkeyed	Black Scale 50
+300	+300V dc	Unkeyed	Black Scale 60
27.5	-27.5V dc	Unkeyed	Black Scale 55
DELAY	30V dc	Unkeyed	Black Scale 38
SWR	Reflected power	Keyed	25 watts max
PWR OUT	RF power output	Keyed	100--130 watts
PAI_{b1}	Plate I of V201	Keyed	Black Scale 60--95
PAI_{b2}	Plate I of V202	Keyed	Black Scale 60--95
ATTEN	I thru var. mag. ferrite	Keyed	Black Scale 4--44

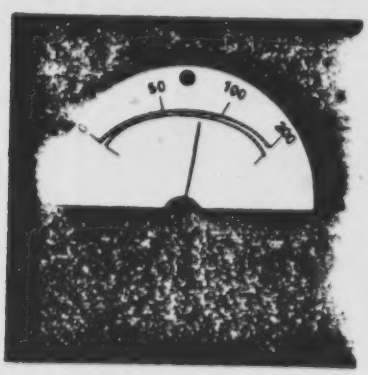


FIGURE 1-14

RADIO SET AN/URC-9 CONTROLS & METER INDICATIONS:

POWER Switch: Controls primary input power to the URC-9

POWER Indicator: Indicates primary power has been applied

DIMMER Control: Controls intensity of panel lights

CHAN SEL Switch: A 21-position switch with the following positions:

REMOTE PRESET--Transfers control to the remote CHANNEL DIAL selector

1 thru 19--Select preset channel 1 through 19

MANUAL--Transfers frequency selection to the MANUAL FREQUENCY switches

MANUAL FREQUENCY Switch: Selects operating frequency when Chan Sel Switch is in MANUAL

TENS Switch--Selects first two digits

Units Switch--Selects third digit

Tenths Switch--Selects fourth digit

CHANNEL Indicator: Indicates preset channel (or manual) in use

FREQUENCY Indicator: Indicates frequency in use

SQUELCH Control: Controls the ability to receive weak signals, and shuts off receiver noise when no signal is received

SQUELCH DISABLE PUSH Switch: Disables squelch circuit when pressed (switch is inoperative when CHAN SEL switch is in REMOTE PRESET)

CALL LIGHT: Lights when squelch is disabled or signal strong enough to override the squelch is received

MODE Switch: Selects the following modes of operation:

NOR--Normal operation (Voice communications)

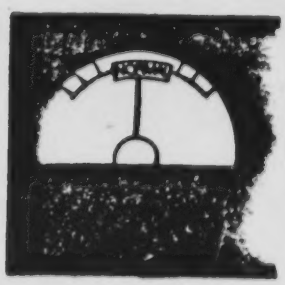
RETRANS--Automatic relaying of another receiver's signals

TONE--1000 Hz modulation of the carrier for Homing Beacon operation

RADIO SET AN/URC-9 (continued)

Meter & METER Switch: Meter monitors any one of 11 functions selected by the METER Switch:

METER POSITION:	FUNCTION:	TRANSMITTER KEYED/UNKEYED:	NORMAL INDICATIONS:
OFF	Meter disconnected		
S METER	Received signal strength	Unkeyed	Depends on signal
SWR	Reflected power	Keyed	Low end of NORMAL range
PWR	RF power output	Keyed	Center of NORMAL or above
DVR I_b	Plate I of V105	Keyed	In NORMAL range
PA I_g	Grid I of V106	Keyed	Center of NORMAL but not over max dial scale
PA I_b	Plate I of V106	Keyed	In NORMAL range
% MOD	Modulator output	Keyed	With strong microphone input, deflects to center of NORMAL range
BIAS	Voltage from 11V dc	Unkeyed	In NORMAL range
+26.5V	+26.5V dc	Unkeyed	In NORMAL range
+125V	+125V dc	Unkeyed	In NORMAL range
+325V	+325V dc	Unkeyed	In NORMAL range



AN/URC-9 METER

FIGURE 1-15

RADIO SET CONTROL C-1138/UR

The Radio Set Control C-1138/UR is a remote phone unit (RPU), which provides convenient control of certain radiophone transmitter and receiver functions. The RPU's are generally located in remote spaces from the radio transmitting equipment such as the Pilothouse, CIC, etc.

The Radio Set Control C-1138/UR incorporates in its circuitry a means for keying and voice modulating its RF carrier. The C-1138 provides a volume control for adjusting the audio level delivered from the distant receiver for earphones usage. Figure 2-1, below, shows the various C-1138 functions.

FIGURE 2-1

The START switch of the Radio Set Control C-1138/UR enables the application of 115/230 volts AC power. The STOP switch removes this power. The POWER indicator lamp reflects this action. The CARRIER ON indicator lamp shows that the RF carrier of the transmitting equipment is keyed (turned on) and ready for voice modulation. A single jack is provided for a handset or chestset on the C-1138/UR. These have a push-to-talk switch for keying the RF carrier, a microphone for voice modulating the same, and earphones for monitoring the radio receiver audio output. The EARPHONE LEVEL control adjusts the level of audio to the earphones. The MICROPHONE jack provides for keying and modulating the RF carrier only. A KEY jack is available for the C-W keying of the RF carrier.

In the GMTS Communications Configuration, the Radio Set Control C-1138/UR is used to key and voice modulate the Radio Set AN/SRC-20. The AN/URC-9 RT-581 transmit circuits, and the RF Amplifier AM-1565 high voltage and carrier, are turned on when the hand/chest set or the microphone push-to-talk switch is pressed. The control circuits and transmit audio are routed from the C-1138 through the Transfer Switchboard SB-988, the Radio Set Control C-3866, and finally through the RF Amplifier to the Transceiver RT-581. See Figure 2-2. The receive-side audio of the RT-581 is routed through the AM-1565, the Radio Set Control C-3866, and the Receiver Transfer Switchboard SB-973 to the RPU C-1138.

AUDIO AND KEYING INTERCONNECTION RADIO SET CONTROL C-1138/UR AND RADIO SET AN/SRC-20

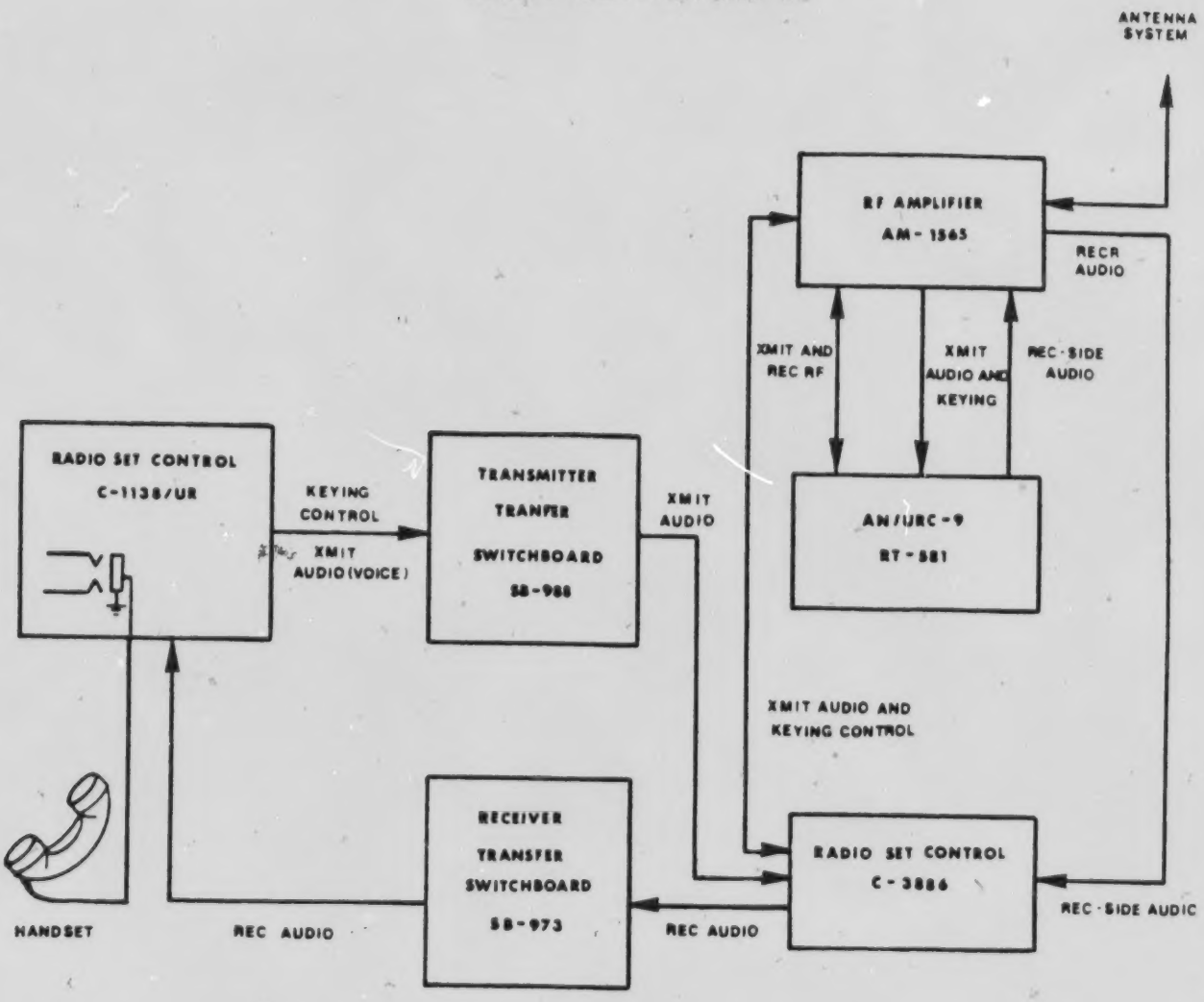


FIGURE 2-2

INDICATOR CONTROL C-3868/SRC

The Indicator Control C-3868/SRC is a remote unit which provides selection of a radio set's RF preset channels and indicates the channel selected. Usually the Indicator Control C-3868/SRC is located with the Radio Set Control C-1138/UR in convenient spaces such as the Pilothouse, CIC, etc., distant from the radio equipment.

The selection of a preset channel is accomplished at the Indicator Control C-3868/SRC by dialing the CHANNEL SELECTOR. See Figure 3-1. The CHANNEL INDICATOR dial indicates the last RF preset channel selected by the C-3868/SRC. The CHANNEL INDICATOR remains in the LOCAL position until the C-3868/SRC is given remote control by the distant radio equipment. Both the CHANNEL INDICATOR and the CHANNEL SELECTOR are turned on and off by the C-3868/SRC ON-OFF switch.

INDICATOR CONTROL C-3868/SRC

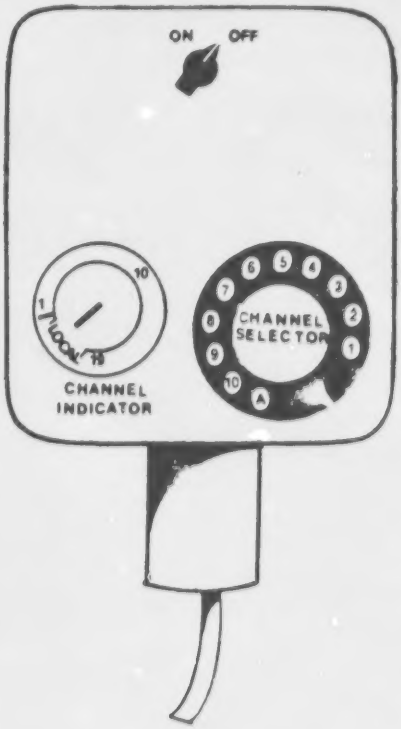


FIGURE 3-1

In the GMTS Communications Configuration, the Indicator Control C-3868/SRC is used to select and indicate the 19 preset channels of the Radio Set AN/SRC-20: AN/URC-9 RT-581 Transceiver, and RF Amplifier AM-1565. Figure 3-2 shows the interconnections between the C-3868/SRC and the AN/SRC-20. The switch settings required to transfer channel selection to the C-3868/SRC are also shown.

REMOTE DIAL INTERCONNECTION
INDICATOR CONTROL C-3868/SRC AND RADIO SET AN/SRC-20

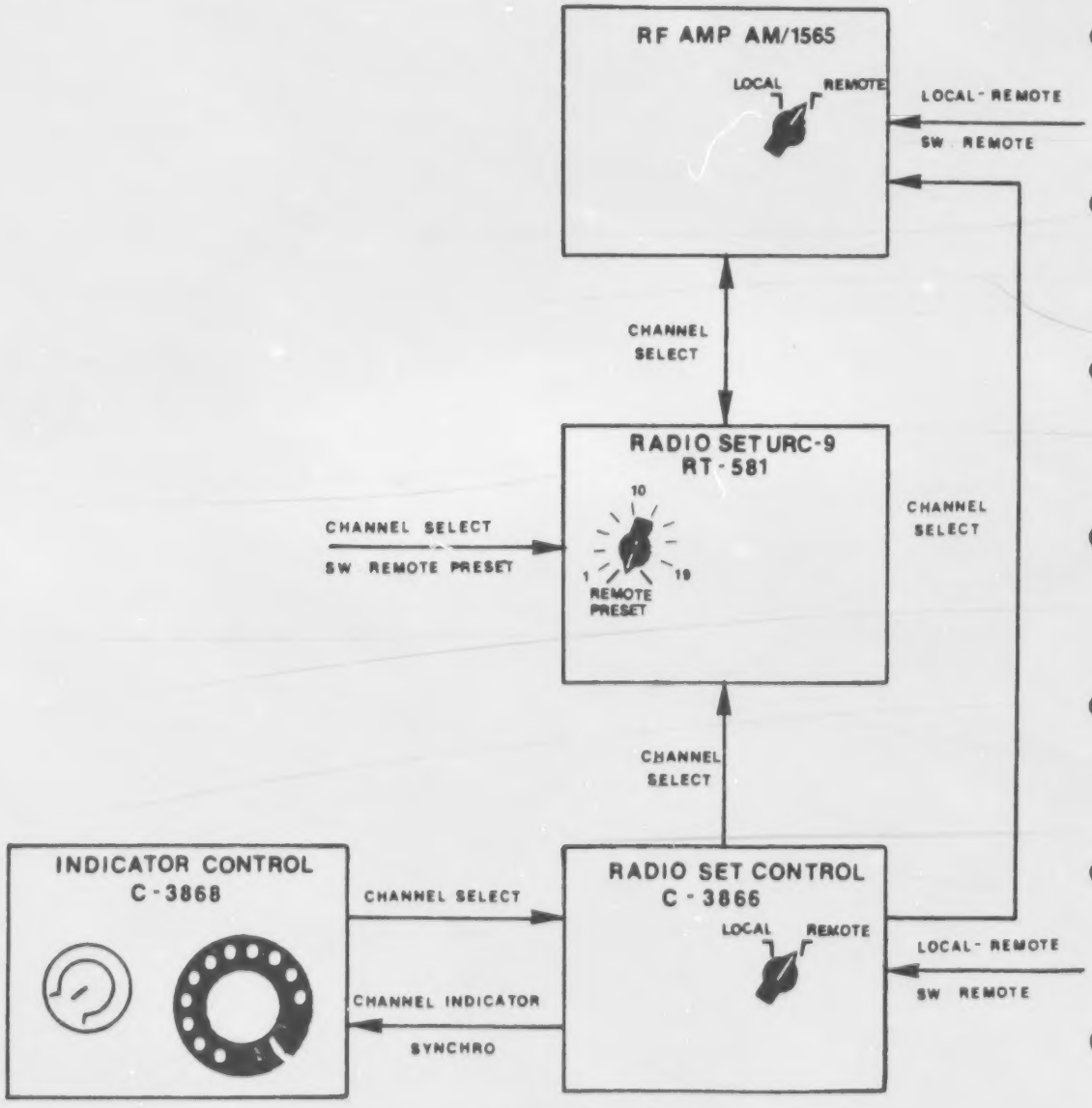


FIGURE 3-2

TRANSMITTER TRANSFER SWITCHBOARD SB-988/SRT

The Transmitter Transfer Switchboard SB-988/SRT interconnects radio transmitters with remote control units and teletype terminal equipments. Up to ten equipments (remotes or TTY terminals) can be selectively tied to a choice of six transmitters. Any single equipment can be tied to any one of six transmitters. In the GMTS Communications Configuration, the SB-988 Switchboard connects the Remote Phone Unit (Radio Set Control C-1138/UR) to the Radio Set AN/URC-9 RT-581 Tranceiver.

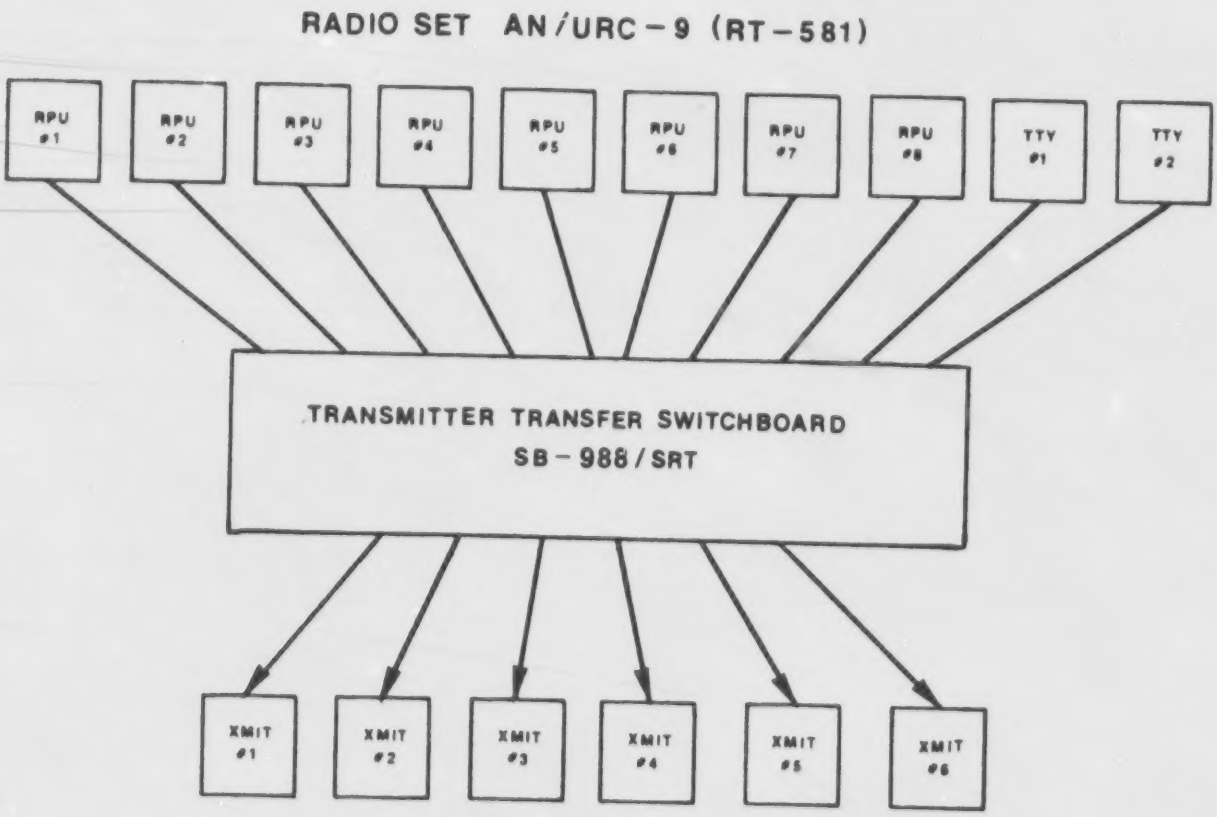


Figure 4-1

The Transmitter Transfer Switchboard SB-988 has ten switches. The wiper arm of each switch is tied to one Remote Phone Unit (RPU). RPU #1 is tied to Switch #1, RPU #2 is tied to Switch #2, RPU #3 is tied to Switch #3, etc., up to a maximum of ten RPU's.

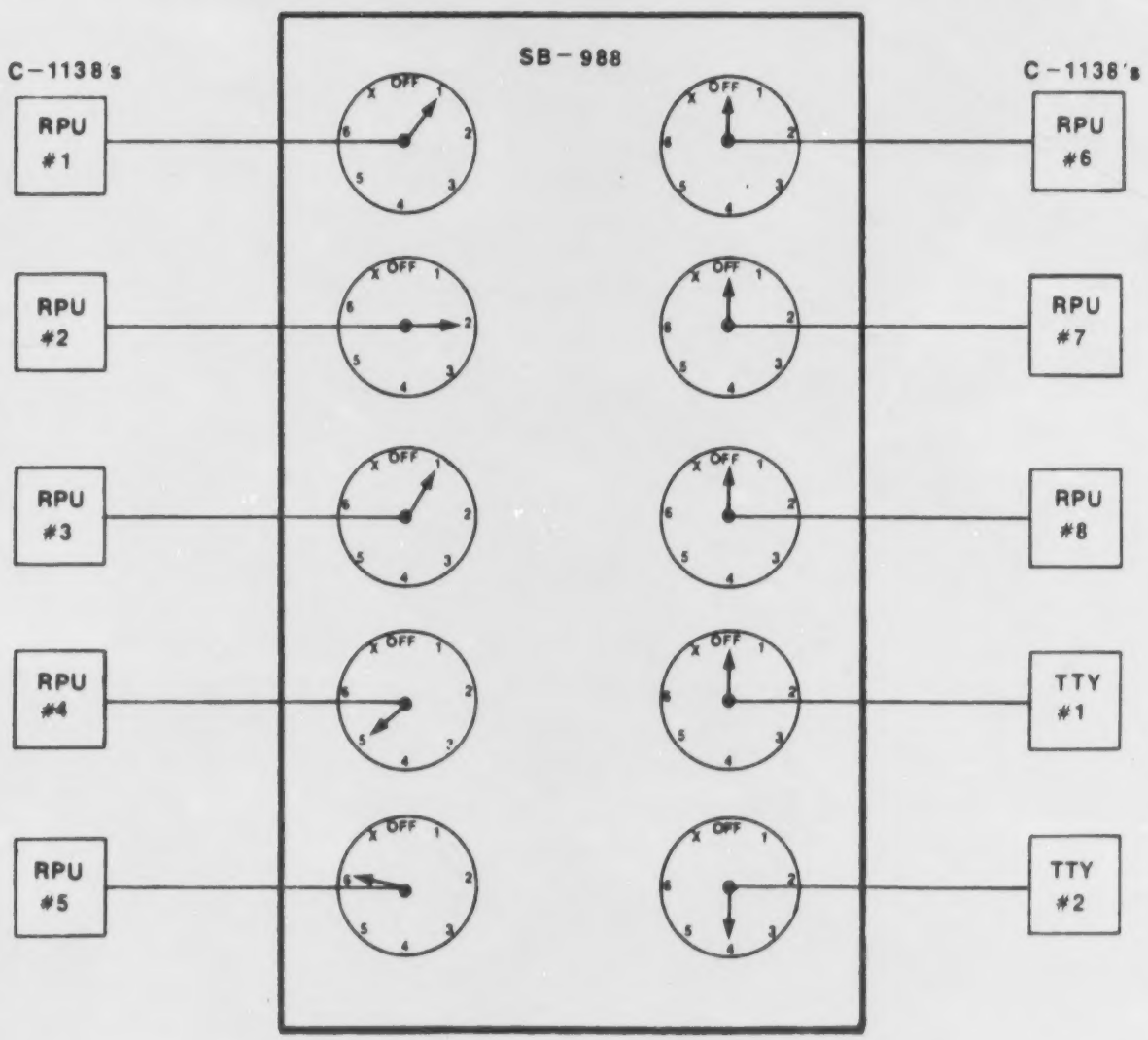


Figure 4-2

Each SB-988 switch has eight positions. Six of these positions can be tied to transmitters. Switch Position #1 is tied to Transmitter #1, Switch Position #2 is tied to Transmitter #2, Switch Position #3 is tied to Transmitter #3, etc., up to a maximum of six transmitters. Each transmitter is tied to the same switch position on each of the ten switches. Thus Switch #1 is tied to Transmitter #1, #2, #3, etc., as is Switch #2, Switch #3, etc. The X position ties the RPU to another switchboard, doubling the number of transmitters that can be selected.

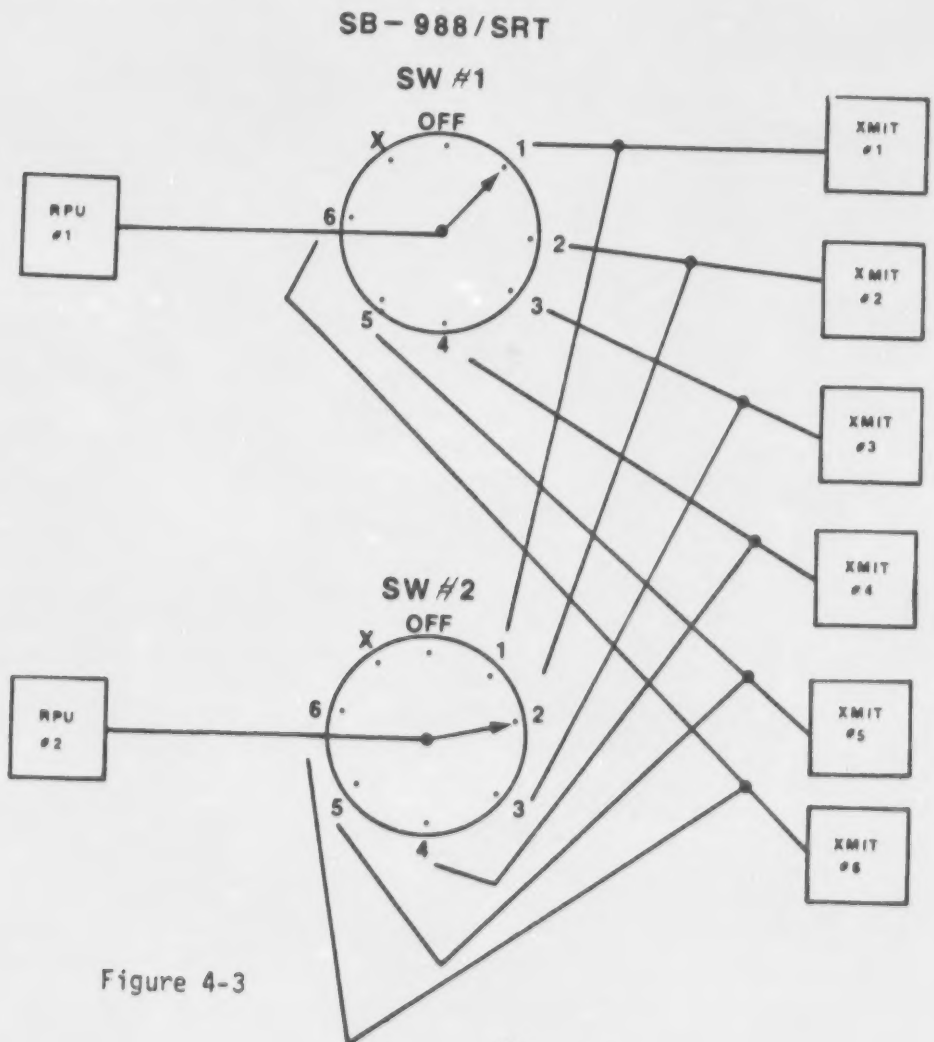


Figure 4-3

Each switch position of the Transmitter Transfer Switchboard SB-988 is rotary, and handles up to 12 wires. This provides the required facilities to handle the standard Navy 12-wire transmitter control circuits. These include audio (voice or teletypwriter), squelch disable, Transmit/Recieve control, 12V DC, Power Indicator light (carrier on), and AC Power On-off light. The arrangement of switches is such that it is impossible to parallel the transmitter circuits.

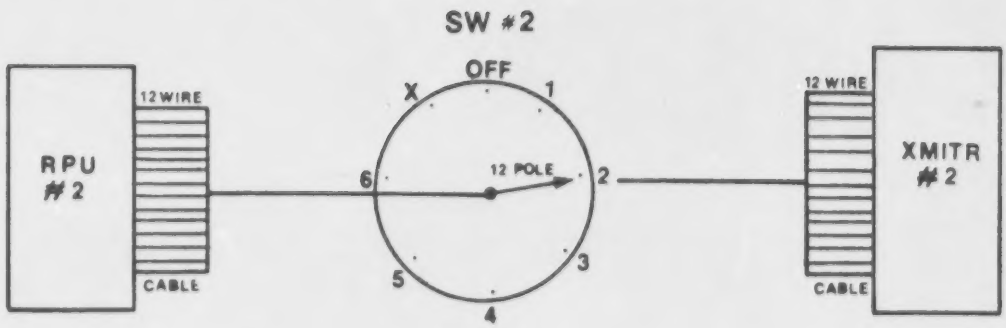


Figure 4-4

RECEIVER TRANSFER SWITCHBOARD SB-973/SRR

The Receiver Transfer Switchboard SB-973/SRR transfers the audio outputs from a radio receiver to a speaker, a remote control unit headset, or to a teletype terminal. Up to ten equipments can be selectively tied to a choice of five receivers. Any single equipment (speaker, headset, TTY terminal) can be tied to any one of five receivers. In the GMTS Communications Configuration, the SB-973 Switchboard connects the Remote Phone Units (RPU): Radio Set Control C-1138/UR, to the Radio Set AN/URC-9 RT-581 Transceiver.

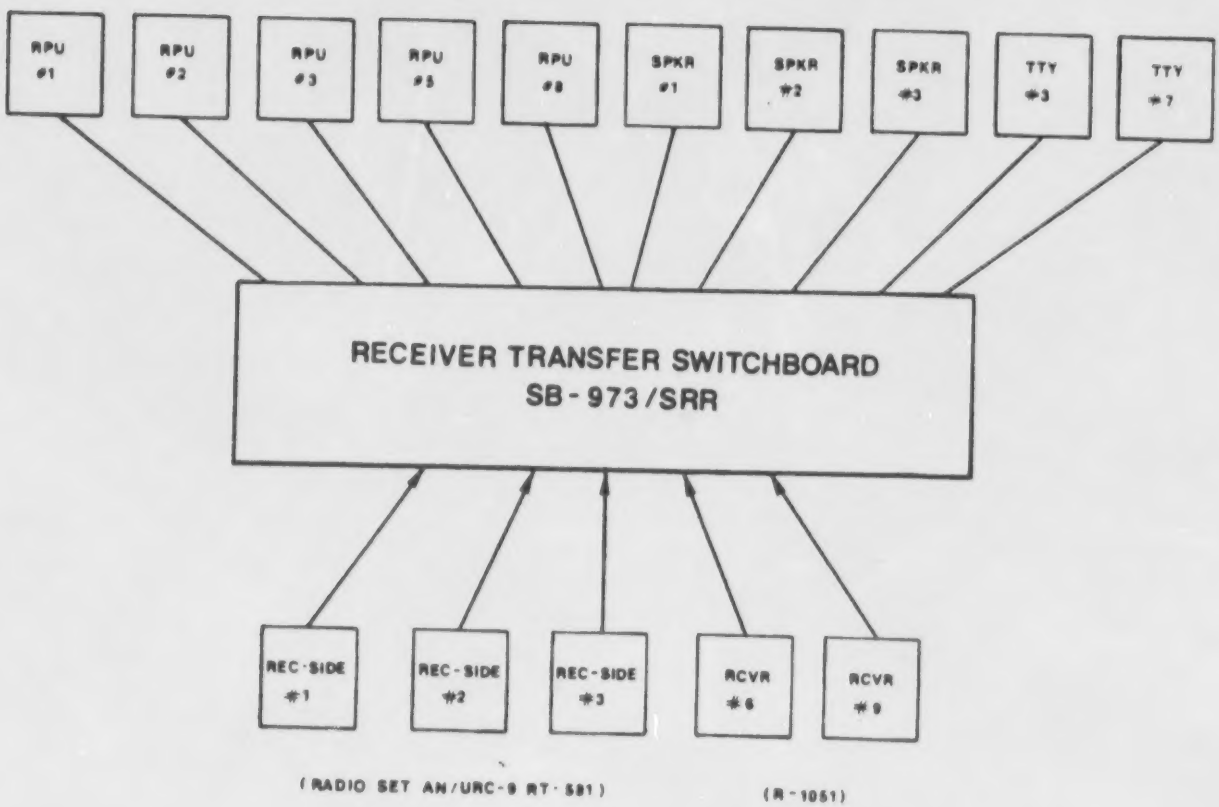


FIGURE 5-1

The Receiver Transfer Switchboard SB-973 has ten switches. The wiper arm of each switch in use is tied to one equipment: Remote Phone Unit, speaker or teletypwriter terminal. For instance in Figure 5-2 below, Switch #1 is tied to RPU #1, Switch #5 is tied to RPU #8, Switch #6 is tied to Speaker #1, Switch #9 is tied to TTY #3, etc. A maximum of ten equipments may be tied to the radio receivers by the SB-973 Switchboard.

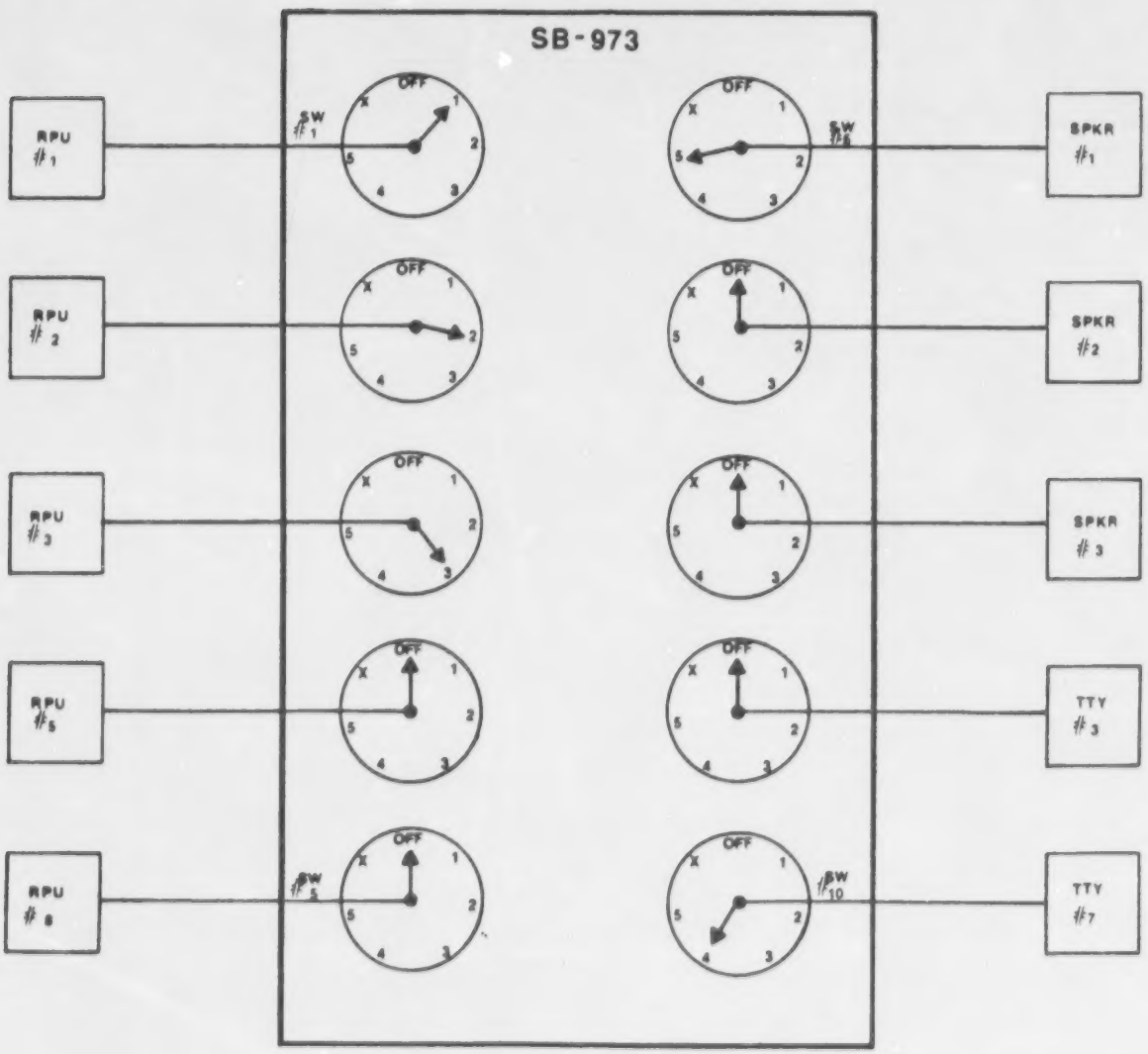


FIGURE 5-2

Each switch of the Receiver Transfer Switchboard SB-973/SRR has seven positions. Five of these switch positions can be tied to receivers. In Figure 5-3 below, Switch Position #1 is tied to receiver #1 (Receive-side of RT-581 Transceiver), Switch Position #2 is tied to Receiver #2, Switch Position #3 is tied to Receiver #3, etc., up to a maximum of five receivers. Each receiver is tied to the same switch position on each of the ten switches. Thus Switch #1 is tied to Receiver #1, #2, #3, etc., as is Switch #2, Switch #3, etc. The "X" position ties the equipments (RPU, Speaker, TTY) to another switchboard doubling the number of receivers that can be selected for an equipment. In the diagram below, Receiver #1 is shown tied to RPU #1, and Receiver #6 is tied to Teletypwriter Terminal #7.

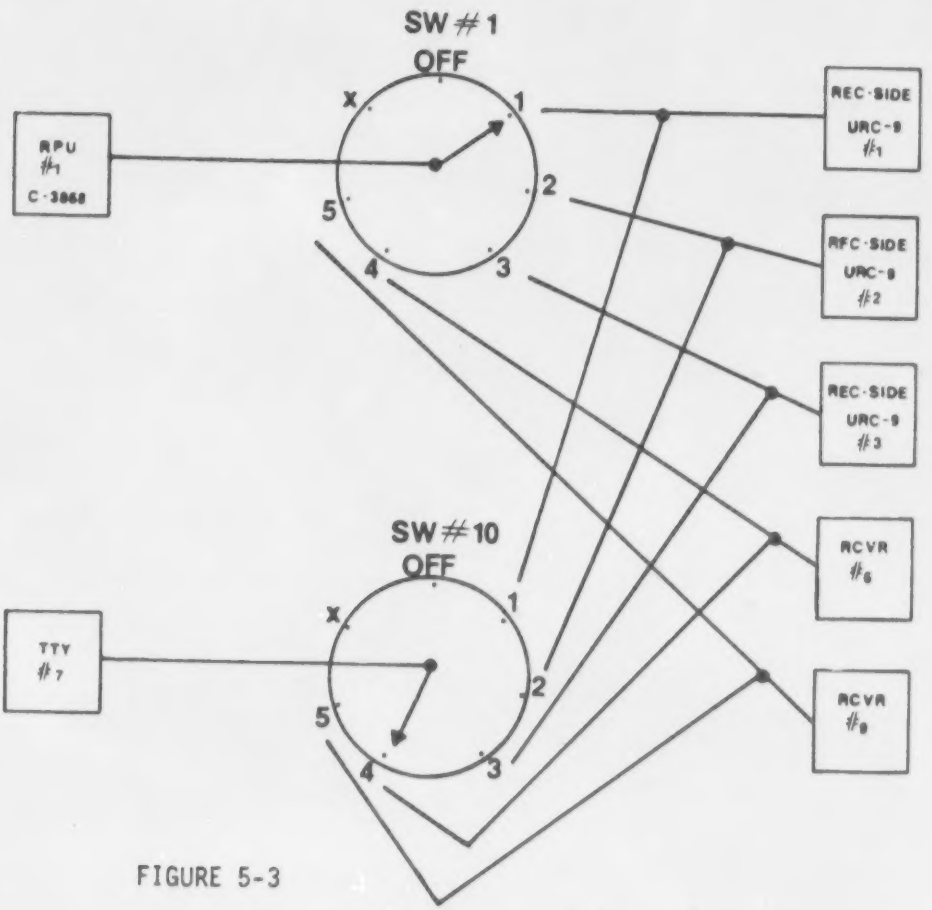


FIGURE 5-3

The switches of the Receiver Transfer Switchboard SB-973 are rotary, and handle a two-wire circuit. These switches connect the receive-side audio to the headset jacks of the remote units. As part of the AN/SRC-20 Radio Set, the receive-side audio is routed through the RF Amplifier AM-1565, and the Radio Set Control C-3866 to the Receiver Transfer Switchboard SB-973 and thence to the RPU Radio Set Control C-1138/UR. Only audio, rather than control and power, is transferred through the switchboard.

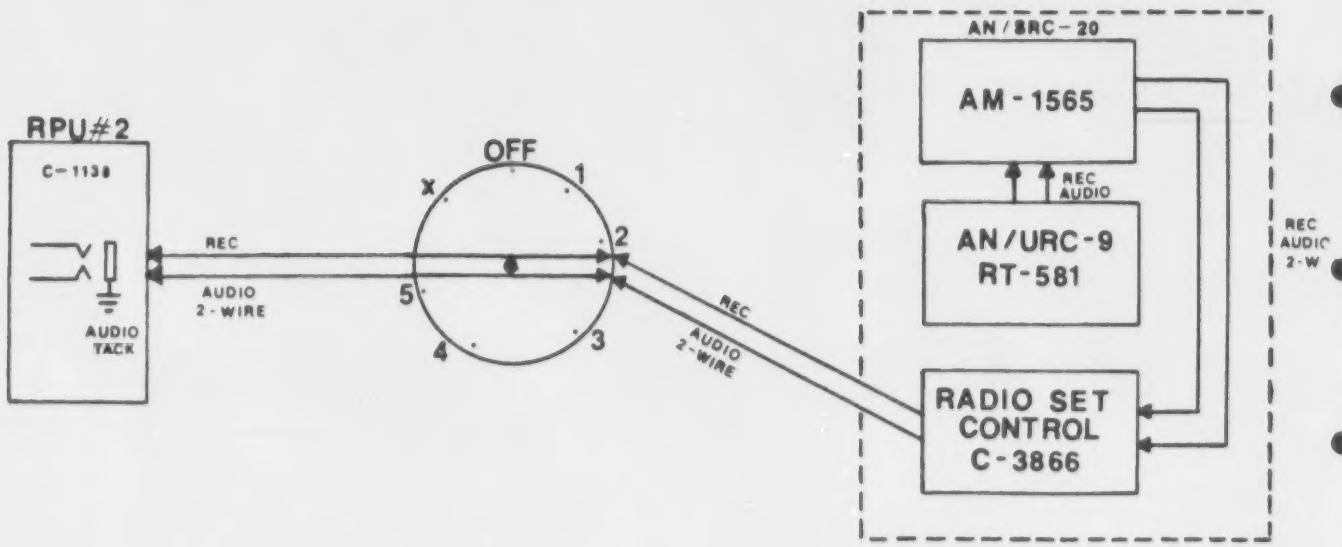


FIGURE 5-4

ANTENNA COUPLER GROUP AN/SRA-33

Because of the large number of radio transmitters and receivers required on board a single Navy ship, it is infeasible to use a separate antenna for each equipment. The Antenna Coupler Group AN/SRA-33 permits simultaneous operation of up to four transmitter and/or receiver combinations into a single UHF antenna. The SRA-33 contains monitoring, control and protective circuits. It provides efficient coupling and impedance matching between the radio equipment and the antenna. The SRA-33 provides isolation between transmitters, and protects the receivers from transmitter RF high voltages.

The Antenna Coupler Group AN/SRA-33 is composed of three different types of units:

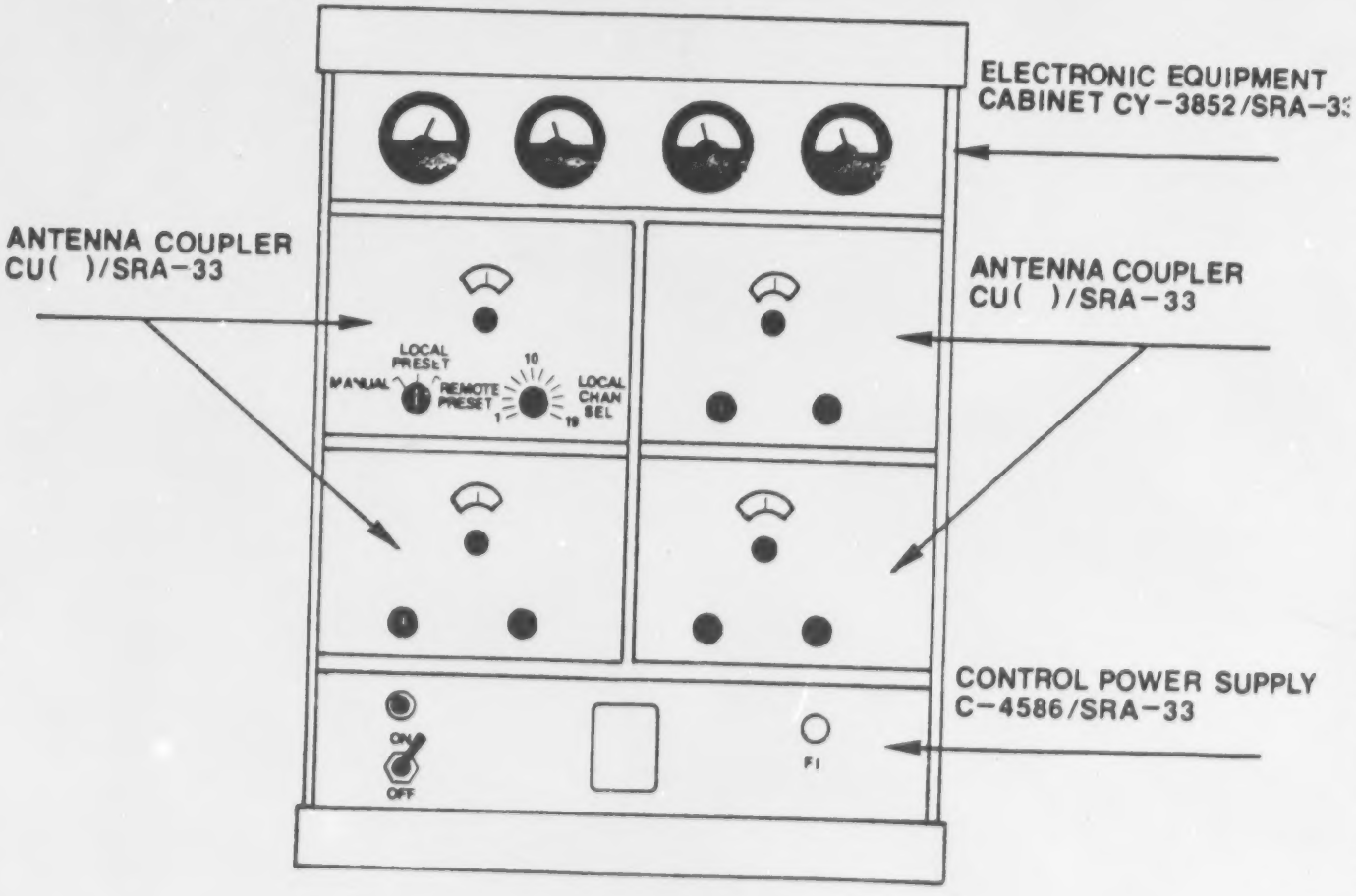


Figure 6-1

The Antenna Coupler CU-(1132)/SRA-33 is the heart of the Antenna Coupler Group. It couples one transmitter, or one receiver, or one transceiver to an antenna. Since these radio equipments are tunable to different frequencies, the Antenna Coupler is tunable over the same frequency range. This provides maximum impedance matching (and power transfer) for any radio frequency selected for transmission or reception. The Antenna Coupler frequencies can be tuned manually, or may be preset in 19 channels. These can be selected locally at the Coupler, or remotely at the radio set or the Control Indicator. See Figure 6-2 below.

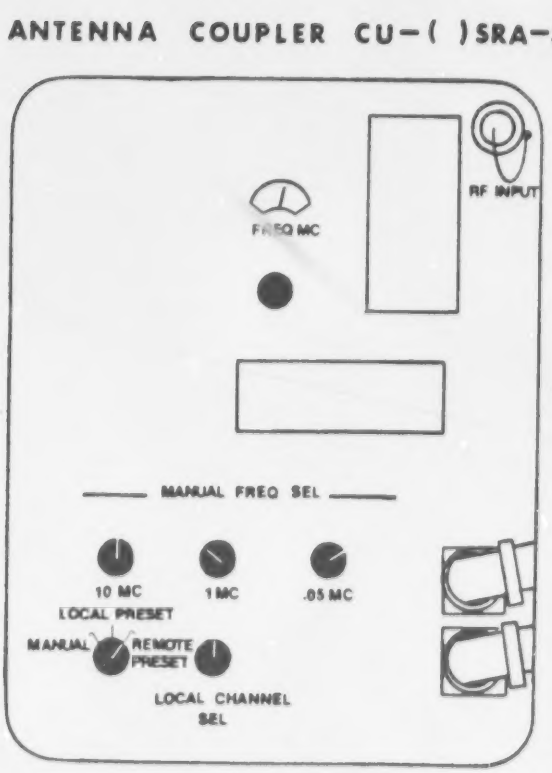


Figure 6-2

The Antenna Coupler CU-(1132)-SRA-33 mode of operation is controlled by the MANUAL-LOCAL PRESET-REMOTE PRESET switch. When it is placed in MANUAL, the Coupler frequency is controlled by the MANUAL FREQ SEL switches. The selected frequency is displayed through the FREQ MC window. When the switch is set to LOCAL PRESET, the selection of the preset channels is set by the LOCAL CHANNEL SEL switch, channels 1 through 19. When the Switch is set to REMOTE PRESET the connected radio set (AN/SRC-20) or the remote unit (Control Indicator C-3868/SRC) controls the selection of the preset channels. There are four identical Antenna Couplers: CU-1131/SRA-33 through CU-1134/SRA-33. Each one has its own tuning system and can be operated independently in the three modes.

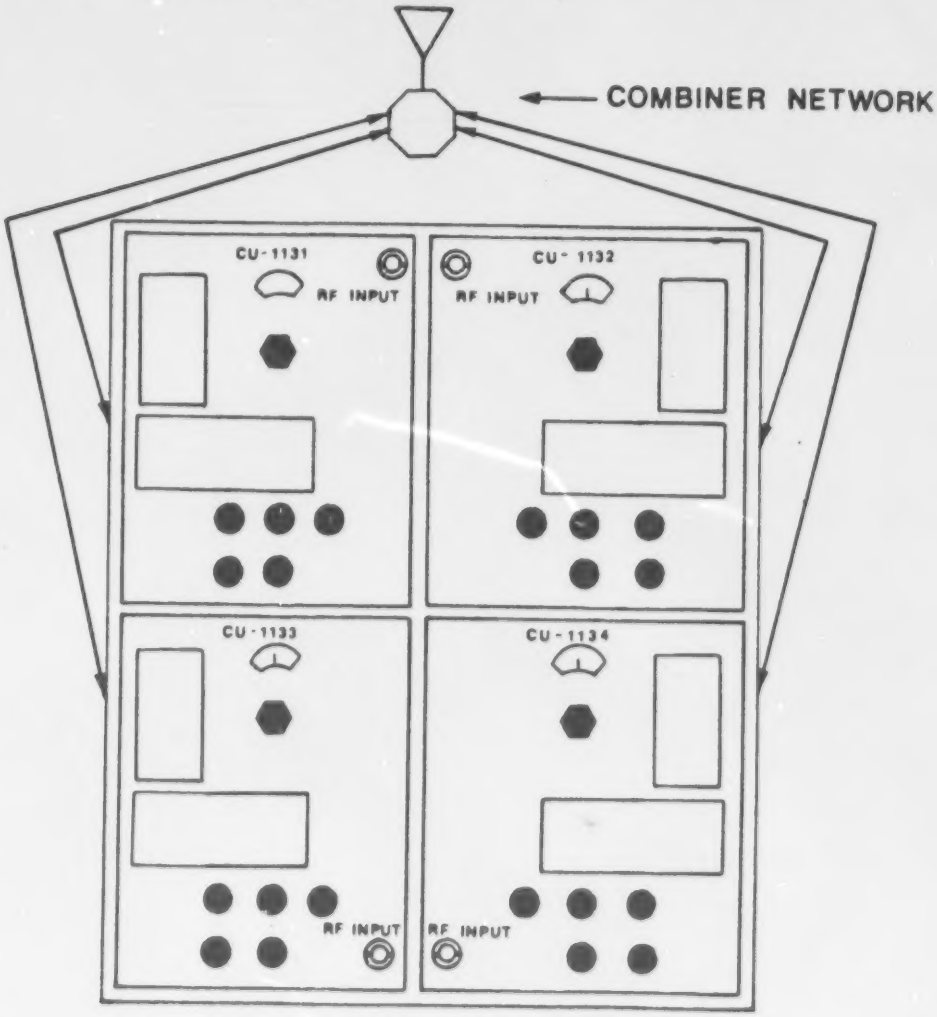


Figure 6-3

The Control Power Supply C-4586/SRA-33 contains the DC power supplies and fusing for the Antenna Coupler Group AN/SRA-33. It contains Lockout circuitry, which protects the associated radio transmitters, receivers, and antenna couplers within the Antenna Coupler Group. The Lockout Circuitry disables the involved transmitter keying circuit, (see Figure 1-11, Radio Set AN/SRC-20 Normal Mode Keying) and disconnects the RF output to the UHF antenna from the involved antenna coupler. This occurs when the antenna coupler is tuning or when another antenna coupler-transmitter in the same Group is set to a frequency within five megacycles and keyed. The ON-OFF switch, see Figure 6-4 below, turns on and off the power to the Antenna Coupler Group. The Power Supply C-4586 also contains voltage divider calibration adjustments for the four antenna coupler RF power meters located in the Electronic Cabinet CY-3852/SRA-33.

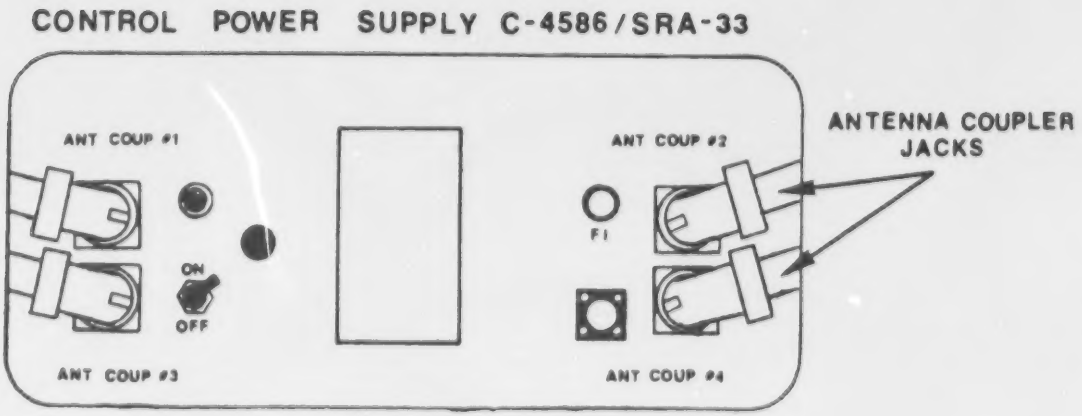


Figure 6-4

The Electronic Equipment Cabinet CY-3852/SRA-33 houses the units of the Antenna Coupler Group. An RF power meter panel is located across the top of the CY-3852 and is considered part of it. See Figure 6-5. Each meter monitors the forward or reflected RF power (as selected by the FORWARD POWER-REFLECTED POWER switch) provided from its associated antenna coupler. RF Power Meter #1 monitors Antenna Coupler #1, RF Power Meter #2 monitors Antenna Coupler #2, etc. When the associated transmitter is keyed, the reflected power should be less than 10% of the forward power. In the GMTS Communications Configuration, the Radio Set AN/SRC-20 (RF Power Amp. AM-1565 output) forward power is approximately 100 watts. The reflected power should be less than 10 watts.

The Electronic Equipment Cabinet CY-3852/SRA-33 also contains the Combiner Network. This network combines into a single common line the RF output from each of the four antenna couplers. The combined RF signal is then applied to the transmission line for delivery to the antenna.

ELECTRONIC EQUIPMENT CABINET CY-3852 / SRA-33

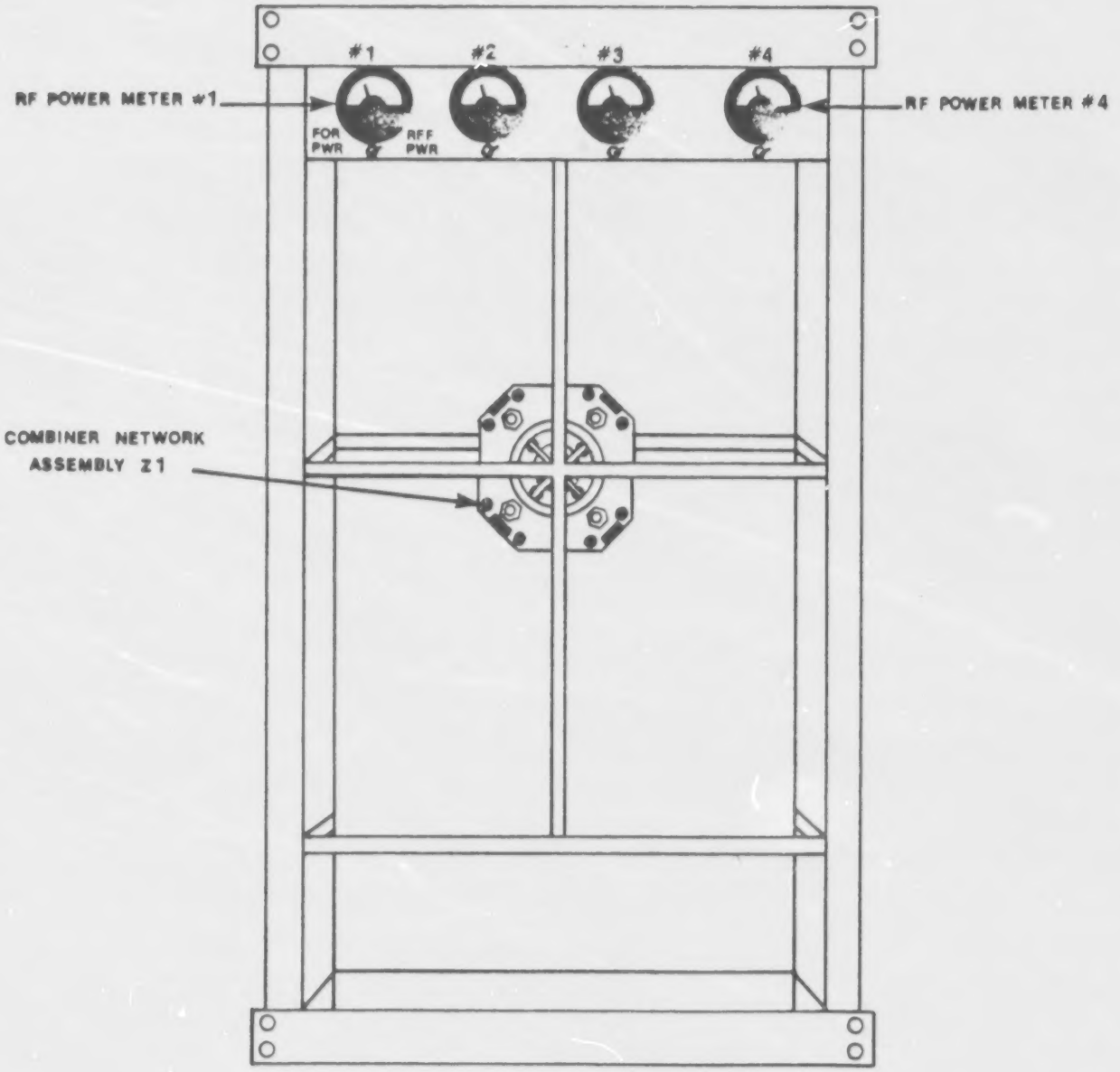


Figure 6-5

MULTIMETER AN/PSM-4

The multimeter AN/PSM-4 is a battery operated, portable volt-ohm milliammeter. It can be used to measure DC current, DC resistance and AC or DC voltages.

There are three controls on the front panel: (1) the function switch which allows selection of the appropriate meter function, (2) the range or multiplier switch that controls the input required for a full-scale reading on the meter and (3) the zero ohms adjust used to battery voltage change for ohm operation. GMTS only uses the PSM-4 in the ohm, R-1 scale position, for checking fuses.

MULTIMETER AN/PSM-4

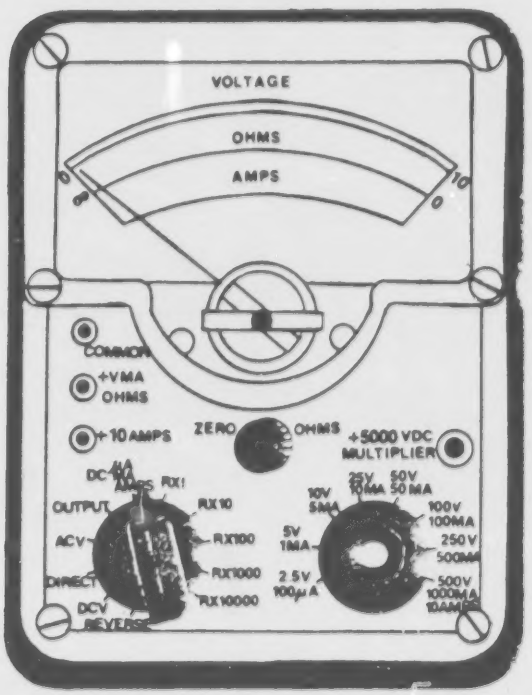


FIGURE 7-1.

WATTMETER AN/URM-120

The AN/URM-120 in-line wattmeter is designed to measure forward and reflected RF power from 10 to 1000 watts within a frequency range of 2 to 1000 MHz. The frequency range is divided into three smaller ranges, 2-30 MHz, 25-250 MHz and 200-1000 MHz each using a separate coupler detector.

The coupler detector has a knurled knob (drum) projecting through the wattmeter to the top of the case. A nameplate on the knurled knob describes the wattmeter's power readings. Centered on the nameplate is a power range selector knob which can be rotated 360 degrees for selection of the desired power range. The coupler detector, however, rotates only 180 degrees to allow reading of forward or reflected power. The arrow on the nameplate points in the direction of power flow. GMTS uses only the detector coupler which covers the 200-1000 MHz frequency range with the power range set to 100 watts.

WATTMETER AN/URM-20

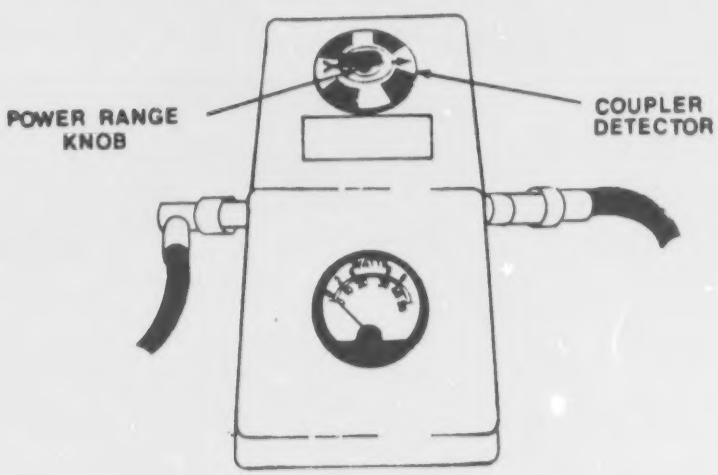


FIGURE 8-1.

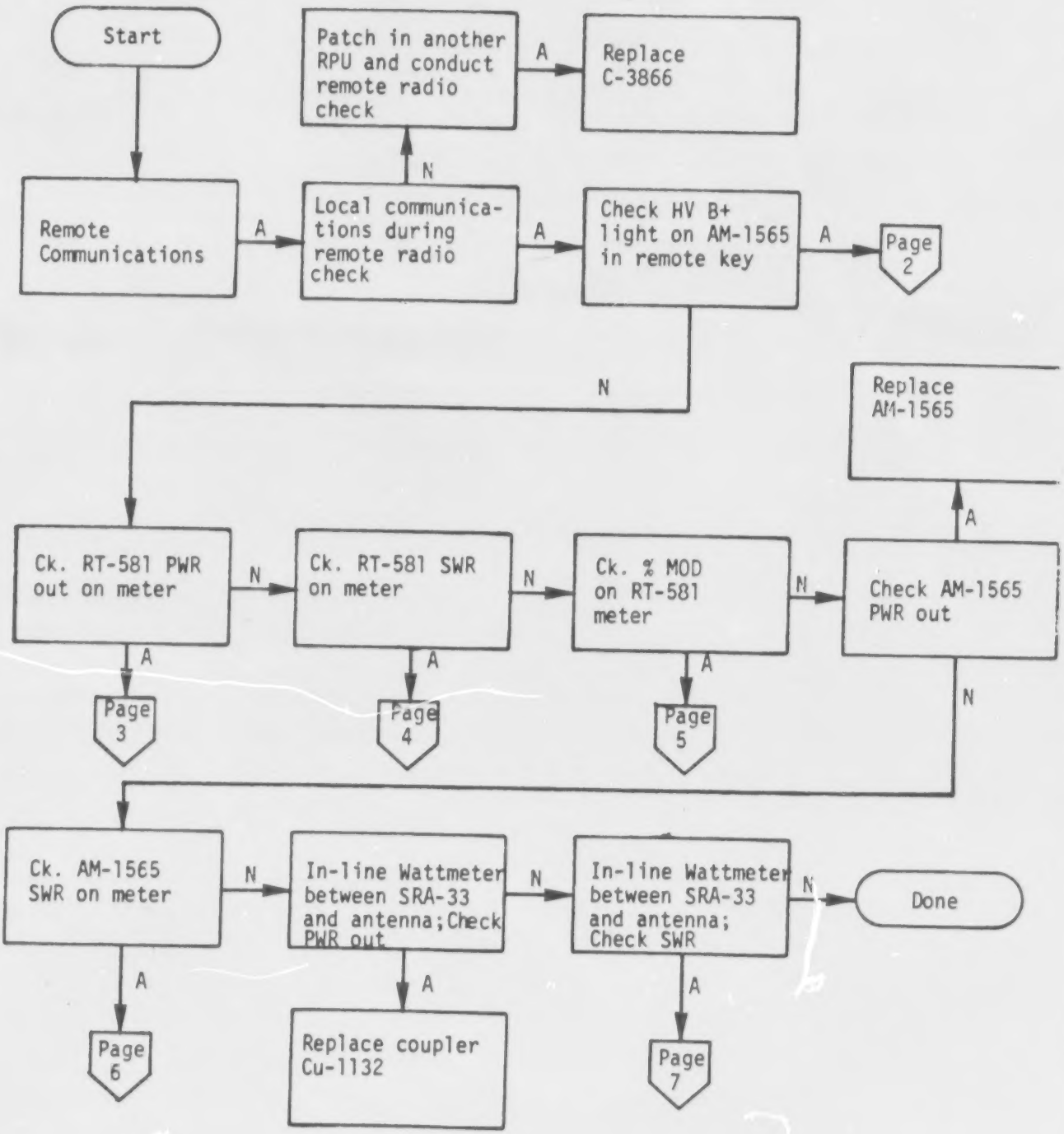
DUMMY LOAD DA-274

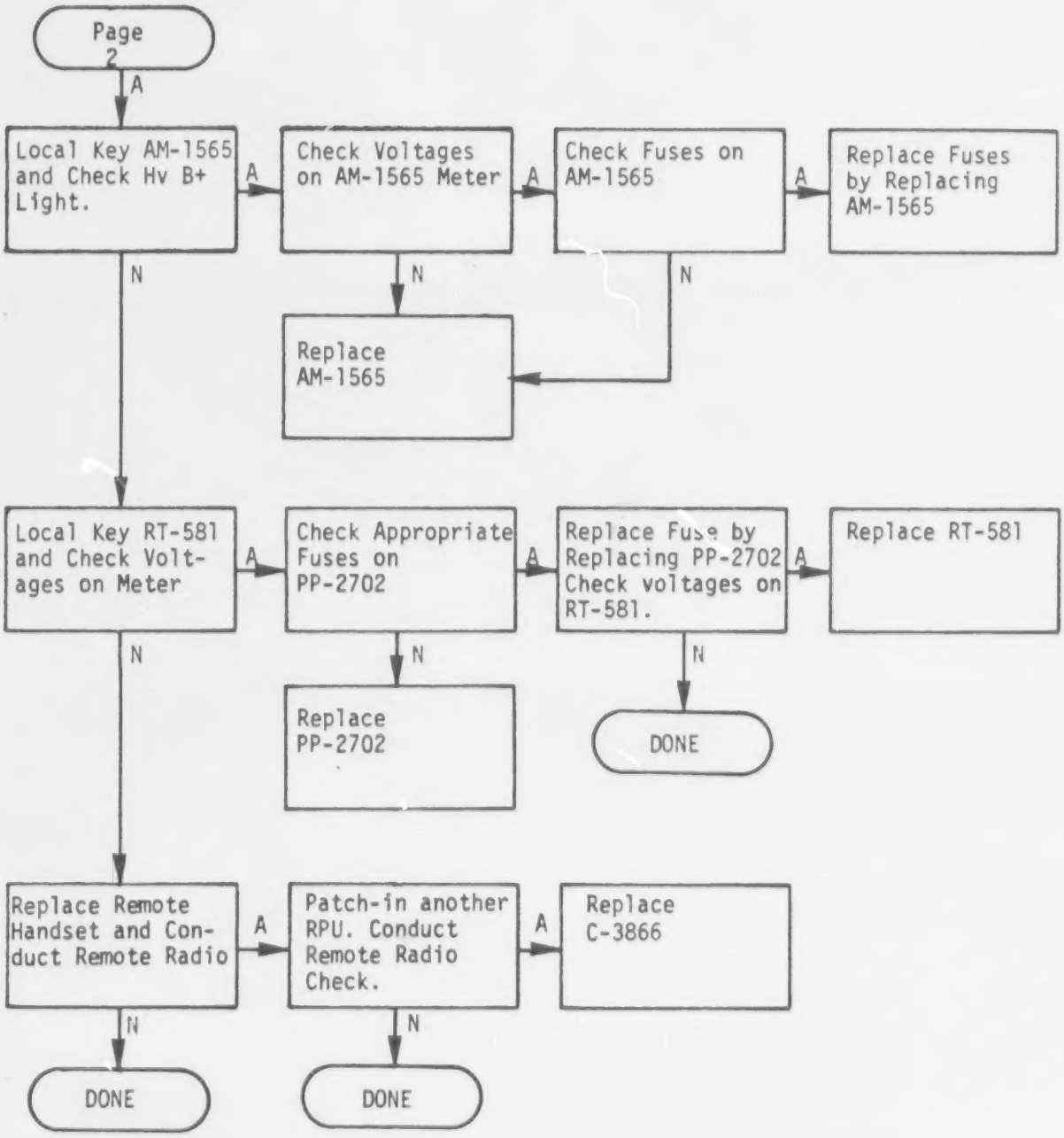
The DA-274 is an oil filled dummy load with an input resistance of 50 ohms, a frequency range of 2 to 250 MHz and power dissipating capabilities of 600 watts.

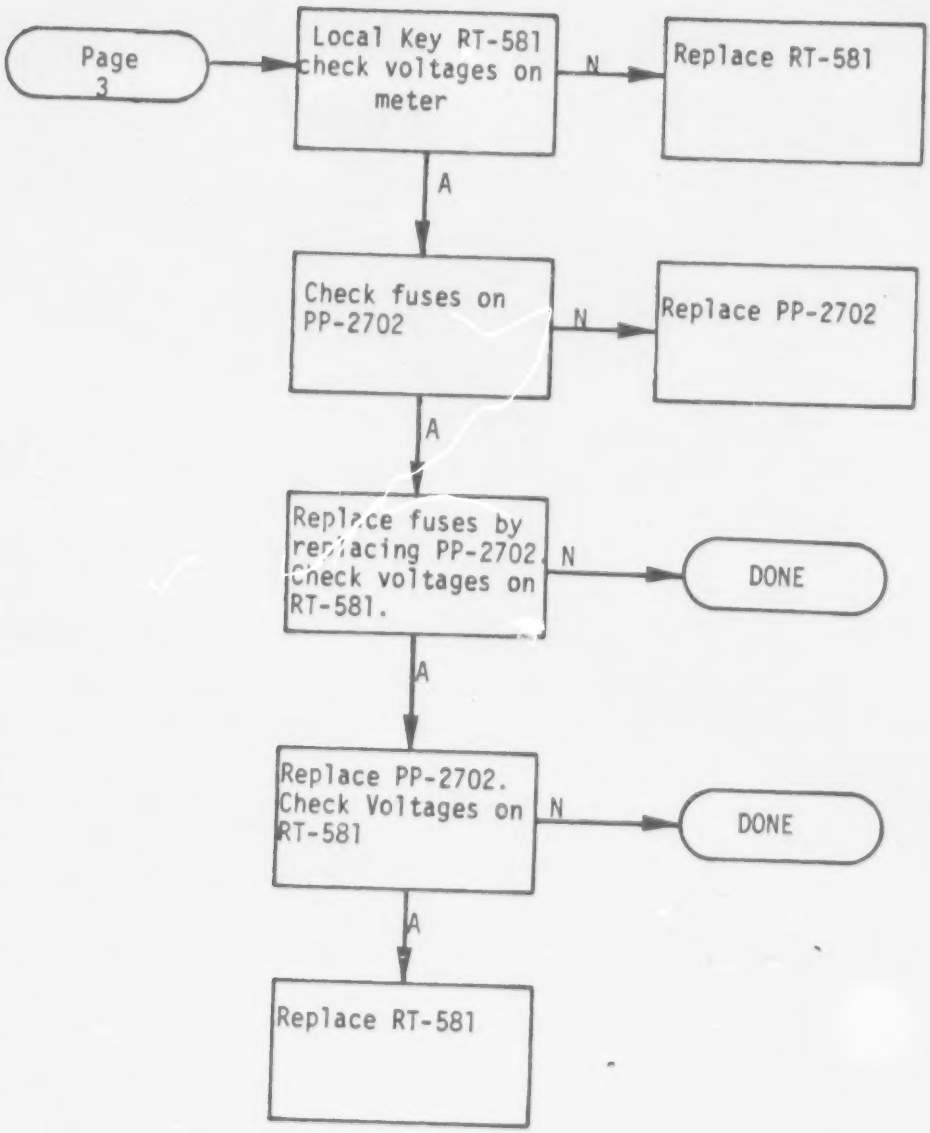
APPENDIX B

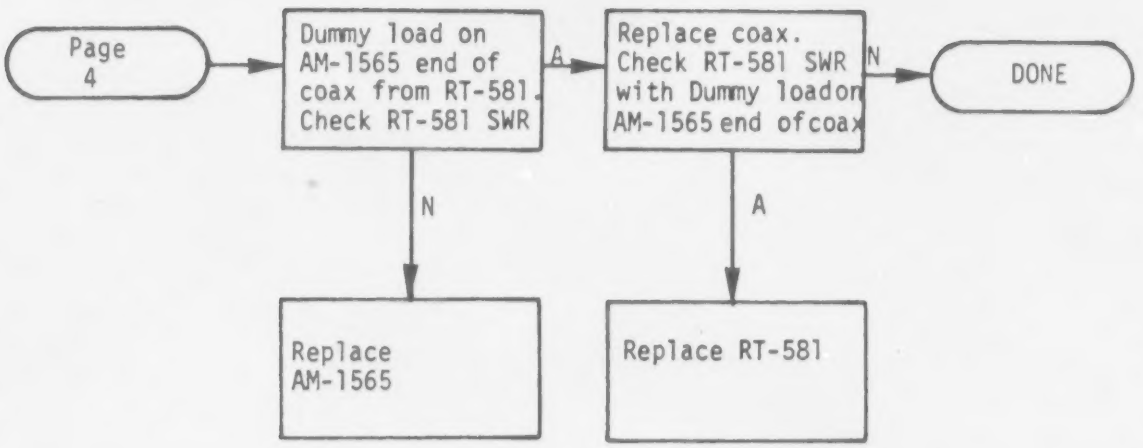
UHF VOICE COMMUNICATIONS SYSTEM

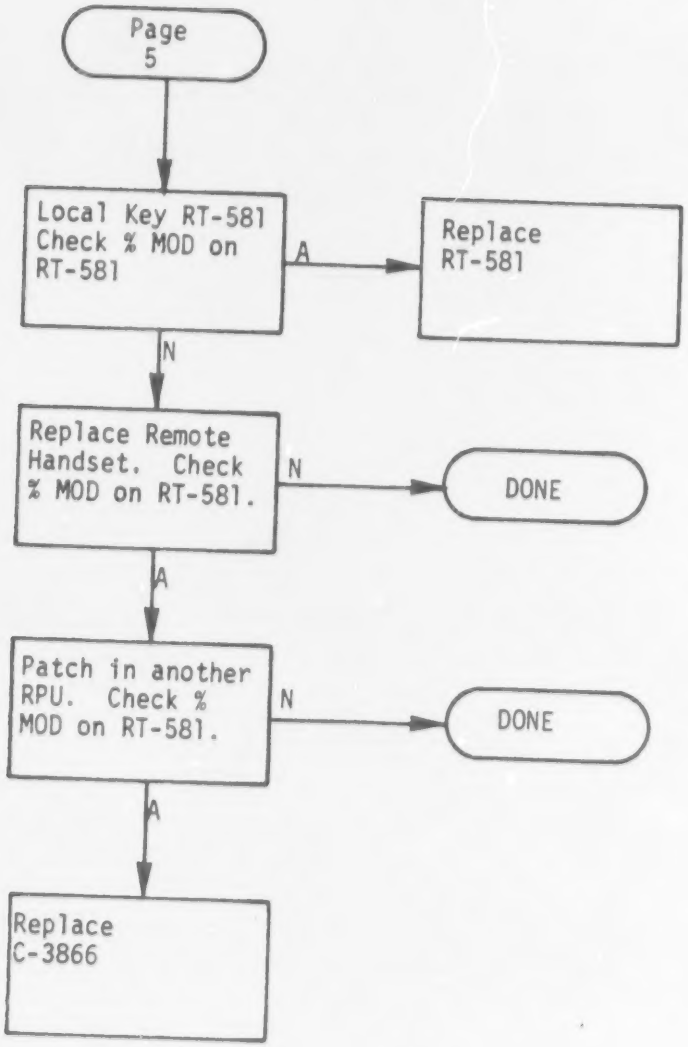
TROUBLESHOOTING TREE

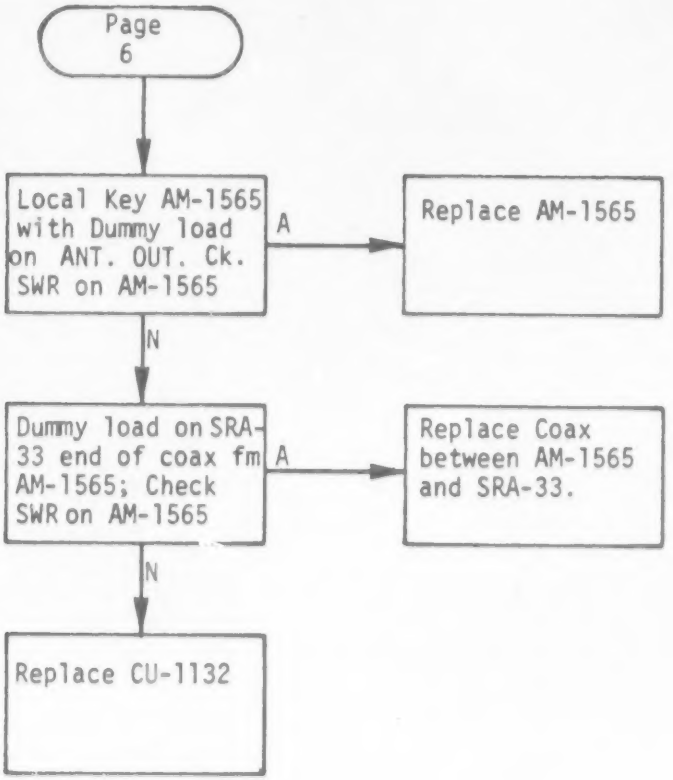

Start
Patch in another RPU and conduct remote radio check
A
Replace C-3866
N
Remote Communications
A
Local communications during remote radio check
A
Check HV B+ light on AM-1565 in remote key
A
Page 2
N
Replace AM-1565
A
Ck. RT-581 PWR out on meter
N
Ck. RT-581 SWR on meter
N
Ck. % MOD on RT-581 meter
N
Check AM-1565 PWR out
A
A
A
A
Page 3
Page 4
Page 5
N
Ck. AM-1565 SWR on meter
N
In-line Wattmeter between SRA-33 and antenna; Check PWR out
N
In-line Wattmeter between SRA-33 and antenna; Check SWR
N
Done
A
A
A
Page 6
Replace coupler Cu-1132
Page 7

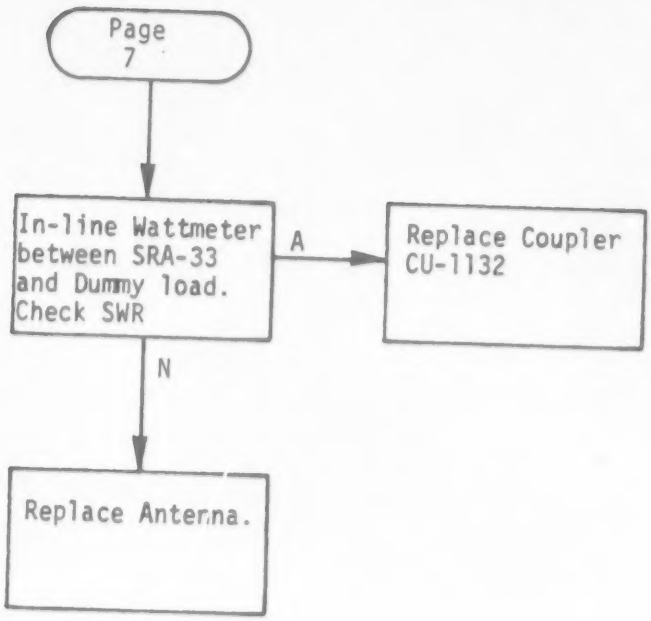

Page 2
A
Local Key AM-1565 and Check Hv B+ Light.
A
Check Voltages on AM-1565 Meter
A
Check Fuses on AM-1565
A
Replace Fuses by Replacing AM-1565
N
N
N
Replace AM-1565
Local Key RT-581 and Check Voltages on Meter
A
Check Appropriate Fuses on PP-2702
A
Replace Fuse by Replacing PP-2702 Check voltages on RT-581.
A
Replace RT-581
N
N
N
Replace PP-2702
DONE
Replace Remote Handset and Conduct Remote Radio
A
Patch-in another RPU. Conduct Remote Radio Check.
A
Replace C-3866
N
N
DONE
DONE


Page 3
Local Key RT-581 check voltages on meter
N
Replace RT-581
A
Check fuses on PP-2702
N
Replace PP-2702
A
Replace fuses by replacing PP-2702. Check voltages on RT-581.
N
DONE
A
Replace PP-2702. Check Voltages on RT-581
N
DONE
A
Replace RT-581


Page 4
Dummy load on AM-1565 end of coax from RT-581. Check RT-581 SWR
A
Replace coax. Check RT-581 SWR with Dummy loadon AM-1565 end ofcoax
N
DONE
N
A
Replace AM-1565
Replace RT-581


Page 5
Local Key RT-581 Check % MOD on RT-581
A
Replace RT-581
N
Replace Remote Handset. Check % MOD on RT-581.
N
DONE
A
Patch in another RPU. Check % MOD on RT-581.
N
DONE
A
Replace C-3866


Page 6
Local Key AM-1565 with Dummy load on ANT. OUT. Ck. SWR on AM-1565
A
Replace AM-1565
N
Dummy load on SRA-33 end of coax fm AM-1565; Check SWR on AM-1565
A
Replace Coax between AM-1565 and SRA-33.
N
Replace CU-1132


Page 7
In-line Wattmeter between SRA-33 and Dummy load. Check SWR
A
Replace Coupler CU-1132
N
Replace Anterna.